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ABSTRACT

This syllabus provides a list of concepts and understandings related to four areas of energy. They are: (1) the nature of energy (an energy definition, basic categories of energy, forms of energy, laws of energy conversion, and measuring energy); (2) energy sources of the past and present (history of energy use and present major sources of energy); (3) aspects of energy problems in the United States (patterns of consumption, aspects of increasing energy demand, aspects of decreasing energy supply, and implications of an energy imbalance); and (4) approaches to energy problems (conservation and energy alternatives). Listed along with the concepts and understandings are recommended learning activities (provided in an appendix) and, when applicable, reference to resources found in another appendix. These resources include such material as energy unit conversions and a list of oil-based products. Also included in the syllabus is a list of science processes (keyed to the learning activities), a list of program objectives and performance criteria for each of the four energy areas, and a list of references. (JN)

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ENERGY: SOURCES AND ISSUES

Science Syllabus for Middle
and Junior High Schools

block **I**

SE 044 742

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FOREWORD

This publication is the seventh product of the project to significantly update and reorder the Science Syllabus for Middle and Junior High Schools. The project will result in a group of instructional blocks encompassing the content and skills in the biological, physical, and earth sciences appropriate for those grade levels.

The understandings, questions, and learning activities in the publication have been enhanced by the inclusion and referencing of program objectives, performance criteria, and process skills which serve to focus student achievement.

The objectives and performance criteria are provided in a general outline on pages 1 through 4 which conforms to the content subdivisions in the publication. Process skills are keyed to the learning activities (Appendix A), and the learning activities are keyed to the understandings and the questions.

Resources related to these activities are found in Appendix B. Activities of greater scope and detail are referenced throughout the concept outline. Titles and the source of each of these are provided as Appendix C.

The materials in this publication were prepared by Jane E. Cappiello, Bethlehem Central School and Karen E. O'Neil, Monument Mountain Regional High School, Great Barrington, Massachusetts.

Prior to preparation of the final draft, the writers benefited from a review of the materials by the following advisory panel members: Carol A. Burkhardt, St. Johnsville Central School; Joanne Gallagher, Brunswick Central School; John Gallivan, Buffalo City Schools; Ellen Goldstein, Junior High School 167, New York City; and Robert La Roche, North Salem Central School. Dr. Bruce Tulloch, Packer Collegiate Institute, New York City, prepared some preliminary draft materials for the publication, and Donald J. Metz, Brookhaven National Laboratory, Upton, reviewed the final draft.

Throughout the development of this publication, the writers were assisted by the special expertise of the staff of the New York Energy Education Project. Materials produced by the Energy Education Project and the Solar Energy Project are referenced in the text.

Graphics were provided by the Center for Art and Design. The publication's cover was designed by Patricia A. Mulligan.

Douglas S. Reynolds, Chief, and Thomas Boehm, Associate, Bureau of Science Education and Barry Jamason, Associate, Bureau of Curriculum Development coordinated the development of the syllabus.

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CONTENTS

FOREWORD	iii
PROGRAM OBJECTIVES AND PERFORMANCE CRITERIA	1
PROCESSES	5
CONCEPTS & UNDERSTANDINGS - QUESTIONS & ACTIVITIES	7
I The Nature of Energy	7
A An energy definition	7
B Basic categories of energy	7
C Forms of energy	8
D Laws of energy conversion	10
E Measuring energy	11
II Energy Sources of the Past and Present	13
A History of energy use	13
B Present major sources of energy	18
III Aspects of Energy Problems in the United States	29
A Patterns of consumption	30
B Aspects of increasing energy demand	33
C Aspects of decreasing energy supply	35
D Implications of an energy imbalance	38
IV Approaches to Energy Problems	40
A Conservation	41
B Energy alternatives	46
APPENDIX A - LEARNING ACTIVITIES	67
APPENDIX B - RESOURCES	121
APPENDIX C - REFERENCES	133

PROGRAM OBJECTIVES AND PERFORMANCE CRITERIA

The program objectives and performance criteria below are provided as an aid in ordering the direction and synthesizing the outcomes of the instruction related to this block. The objectives and outcomes (performance) described below for this program are merely illustrative and, as such, they permit latitude in the selection of additional content. It is implied that student knowledge, understanding, and skills accrued as a result of content selection and instruction will be demonstrable in the manner, and to the minimum extent, described.

PROGRAM OBJECTIVES

PERFORMANCE CRITERIA

I. THE NATURE OF ENERGY

The student will be able to identify commonplace events where work is being performed and know the form of energy being used.

Given a specific environment such as the home, the school, or the factory, the student will be able to identify several events where work is being performed and associate each with the form of energy responsible for the work done.

The student will be able to distinguish between examples of kinetic and potential energy.

Given an object and its condition, the student will be able to determine whether the energy it possesses is primarily kinetic or potential.

The student will be able to identify various types of energy and describe how they may be converted from one form into another.

Given events involving energy conversions, the student will be able to identify each type of energy involved.

The student will be able to discuss the implications of the first and second laws of thermodynamics for solving the present energy crisis.

Given one of the laws of thermodynamics, the student will be able to describe the implications it has for energy production and conservation.

The student will be able to discriminate between units of energy and units of power and indicate the contexts in which they are used.

Given an energy measurement, the student will be able to identify it as a unit of energy or power and describe a situation to which this unit may be applied.

PROGRAM OBJECTIVES

PERFORMANCE CRITERIA

II. ENERGY SOURCES OF THE PAST AND PRESENT

The student will be able to describe the major events in world and American history which have led to a shift from renewable to nonrenewable energy sources to fulfill increasing demands.

The student will be able to describe the relationship of changing energy sources to technology during the Industrial Revolution.

The student will be able to compare the respective characteristics of major sources of energy.

Given a renewable energy source, the student will be able to describe how its pattern of use changed throughout world history.

Given a nonrenewable energy source, the student will be able to identify events that led to its increasing use in the nation and in the world.

Given a technological development of the Industrial Revolution, the student will explain how the technology led to new or altered energy-use patterns, or how, conversely, discovery of a new type or use of energy led to technological change.

Given two presently used, major energy sources, the student will be able to compare them in terms of their form, location, production, distribution, storage, and uses.

Given electricity as a secondary energy source, the student will be able to explain the production of electricity from primary sources.

III. ASPECTS OF ENERGY PROBLEMS IN THE UNITED STATES

The student will be able to compare present sources of energy as to their rates of consumption and patterns of consumption.

The student will be able to explain the implications that the present rates and patterns of energy consumption in the United States have for meeting future energy needs.

Given a primary energy source, the student will be able to describe how its use is divided among the economic sectors of the United States.

Given all primary energy sources in the United States, the student will be able to sequence them in order of their rates of consumption.

Given present trends in energy consumption, the student will be able to construct two scenarios for life in the United States in the year 2000; one that disregards the implications of present trends and the other that demonstrates appropriate responses to such implications.

PROGRAM OBJECTIVES

The student will be able to discuss the present energy crisis in terms of increasing demands and decreasing domestic supplies.

The student will be able to discuss the effects of the energy crisis on the economy, standard of living, environment, and international relations of the United States.

PERFORMANCE CRITERIA

Given the opportunity, the student will be able to describe several factors which have spurred an increase in energy consumption in the United States.

Given the opportunity, the student will be able to describe several factors which have retarded energy production in the United States.

Given a real or fabricated governmental policy statement regarding energy production or use, the student will be able to debate the merits and disadvantages of the policy upon the U.S. economy, environment, and foreign affairs.

IV. APPROACHES TO ENERGY PROBLEMS

The student will be able to describe general and specific activities which conserve energy through reduced and more efficient consumption.

Given a strategy to lower energy consumption, the student will be able to cite several examples that illustrate this strategy.

Given the home, work, or transportation environment, the student will be able to cite several specific practices which conserve energy.

The student will be able to describe several important results of energy conservation.

Given an economic, environmental, or foreign policy implication of the energy crisis, the student will be able to show how conservation of energy would negate or enhance the implication.

The student will be able to describe techniques which will allow more of the United States' nonrenewable resources to be recovered and used for energy production.

Given a fossil fuel or uranium, the student will be able to identify and describe a method used to obtain a greater and/or more efficient use of the fuel source.

Given a technique for recovery or conversion, the student will be able to associate it with the proper fuel source.

PROGRAM OBJECTIVES

The student will be able to discuss the form, use, and potential of renewable energy sources.

PERFORMANCE CRITERIA

Given a renewable energy source such as geothermal, biomass, wood, tidal, nuclear fusion, or solar, the student will be able to describe how the energy is formed, discuss the technologies being developed for its use, and predict the contributions which the renewable source could make in the next century.

Given a renewable energy source, the student will be able to debate the merits and disadvantages of its widespread use at some point in the twenty-first century.

PROCESSES

One of the major objectives in all science courses is the development of competence in processes used in science. The learning activities beginning on p. 67 in this publication will assist students in attaining this objective. Each activity is keyed to one or more of the processes listed below. For example, activity (I-1) involves processes [1], [2], and [17]. In general, the processes are listed in order of predominance within the activity and appear to the right of the activity's title.

- [1] Observing objects and phenomena
- [2] Describing observations
- [3] Selecting suitable measuring instruments
- [4] Developing skills in using laboratory equipment
- [5] Measuring objects and phenomena
- [6] Performing laboratory techniques
- [7] Estimating measurements within limits of accuracy
- [8] Recognizing a problem
- [9] Formulating a working hypothesis
- [10] Designing appropriate tests of a hypothesis
- [11] Designing suitable procedures for experimental tests
- [12] Processing experimental data
- [13] Organizing data to show a functional relationship
- [14] Interpreting observations and data
- [15] Interpolating and extrapolating
- [16] Evaluating a hypothesis in the light of data obtained
- [17] Formulating generalizations based on relationships
- [18] Recognizing the need for a theoretical model
- [19] Formulating a theoretical model to accommodate knowledge
- [20] Designing relationships satisfied by a model
- [21] Deducing a hypothesis from a theoretical model
- [22] Interpreting and evaluating tests of a model
- [23] Producing a revised, refined, or extended model

CONCEPTS & UNDERSTANDINGS/QUESTIONS & ACTIVITIES

I. THE NATURE OF ENERGY

Every object, event, and change in our universe involves energy. Energy is a natural phenomenon which humans have attempted to describe, explain, and measure.

What are some uses of energy in everyday life?

A An energy definition

Energy is defined as the ability to do work. Work is performed when a force moves matter across a distance.¹

What is energy? (I-1)

B Basic categories of energy

Energy is classified in two forms, each capable of doing work.

1 kinetic energy

Kinetic energy is energy an object has due to its motion. Some things possessing kinetic energy are a rolling rock, water falling over a dam, and a turning blade.²

What is kinetic energy? Give some examples.

2 potential energy

Potential energy is stored energy an object has due to its position or condition. As examples, a compressed spring, a battery, and a candy bar all possess potential energy.³

What is potential energy? Give some examples.

3 potential-kinetic energy conversions

The kinetic energy of a rolling ball is converted into potential energy as the rolling ball climbs a hill and slows down (stops).

How can potential and kinetic energy be converted to each other? (I-2) (I-3)

¹Since most events involve matter in motion, the effects of energy are all around us.

fly wheel of an engine and the heat energy stored in a thermos bottle are examples of stored kinetic energy.

²Because of the great demand for energy, energy storage is important. While energy is usually stored in potential form, it is possible to store it in the kinetic form. The

³Energy is most frequently stored in the potential form. Pumping water to the top of a tower and charging batteries are examples of stored potential energy.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

C Forms of energy

Objects possess different forms of kinetic and potential energy.

1 mechanical energy

Mechanical energy is that form of energy which is acquired or released by moving objects.⁴

What is another form of energy that can be produced from mechanical energy? (I-4)

2 electromagnetic radiation

Vibrating, electrically-charged particles produce electromagnetic radiation in the form of waves moving at the speed of light.

Different types of electromagnetic radiation exist. Light may be defined as that electromagnetic radiation which the human eye can detect.

How can you show that energy comes from the sun? (I-5)

What colors best absorb infrared radiation? (Appendix C-1)

The sun is our major source of electromagnetic radiation and the ultimate energy source.

Explain why most of our energy sources come either directly or indirectly from the sun. What is an exception?

3 heat energy

The energy which an object possesses due to the kinetic energy of its atoms or molecules is called heat energy.

What property of heat explains what happens when a cool object comes in contact with a warm object? (I-6)

The amount of heat energy a solid, liquid, or gas possesses depends upon the number of its atoms or molecules in addition to their kinetic energies.⁵

What type of surface absorbs/radiates heat? (Appendix C-2)

⁴Mechanical energy generally involves the use of machines. A machine is a device that performs one of the following functions: (a) transforms energy from one form to another; (b) transfers energy from one place to another; (c) multiplies the force; (d) changes the direction of

the force; or (e) multiplies the speed.

⁵Temperature is a measure of the average kinetic energy of an object's atoms or molecules but does not directly indicate its heat content.

CONCEPTS AND UNDERSTANDING

When two bodies are brought into contact, heat energy will flow from the object of higher temperature to the one of lower temperature.

Heat is transferred from one place or object to another by conduction⁶, convection⁷, and radiation⁸.

4 nuclear energy

Nuclear energy is that energy released or absorbed during alterations within the nucleus of an atom. Such alterations are accompanied by the release of tremendous amounts of energy.

5 chemical energy

Potential energy which elements and compounds possess due to their chemical composition is called chemical energy.

Chemical reactions often bring about a change in the potential energies of substances, resulting in either an absorption or release of heat energy.⁹

6 gravitational energy

Potential energy which an object possesses due to the gravitational attraction between it and some other body is called gravitational energy.

The earth's gravitational pull provides potential energy for all objects on or above it.¹⁰

⁶Conduction is the transfer of heat from molecule to molecule. Metals are the best conductors of heat.

⁷Convection occurs when the heated material moves. This situation occurs in liquids and gases.

⁸Radiation is the movement of heat energy in the form of electromagnetic waves. An open fireplace (inefficiently) heats by this means.

⁹The fossil fuels coal, oil, and natural gas possess chemical potential energy which, when released by combustion, produces useful heat energy.

¹⁰The amount of gravitational energy these objects possess depends upon their masses and distances from the earth's surface.

QUESTIONS AND ACTIVITIES

In what other ways may heat be transferred?

Why is nuclear energy a more appropriate term than atomic energy? (Appendix C-3)

In what ways may the energy stored in elements and compounds be changed to other forms? (I-7) (I-8) (I-9)

What are some ways that gravitational energy can do work? (I-10)

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

7 electrical

Electricity is a manifestation of either the separation of electrons from protons (static electricity) or the motion of electrons (current electricity).

Current electricity is commonly used to perform work.

Describe ways in which electricity does useful work.
(I-11) (I-12)

D Laws of energy conversion

Two physical laws govern the change from one form of energy into another.

Fill in the table (I-13) to show conversions.

1 the first law of thermodynamics

a the law stated

Energy can neither be created nor destroyed but only changed from one form into another.

b the law's implications

The conversion of matter into energy and energy into matter are considered to be in harmony with this law.

The ability of energy to change forms allows humans to harness those forms most useful to them at a given moment.¹¹

Since the total energy of the universe must remain constant, the present energy crisis reflects a shortage in the availability of resources used for energy rather than in the quantity of energy.

2 the second law of thermodynamics

¹¹Examples would be the chemical energy of fuel converted into mechanical energy for machines, the sun's radiation used to generate electricity in photovoltaic cells, or the heating of water in solar collectors.

CONCEPTS AND UNDERSTANDINGS

a the law stated

No energy conversion from one form into another is 100% efficient. Some of the energy becomes more random and less available to do work.¹²

b the law's implications

Since heat is a more random and less concentrated energy form, it is far easier to convert other energy forms into heat than to do the reverse process.

Generally, the greater number of energy transformations, as when technology is designed to harness and convert energy for various human needs, the smaller the amount of useful energy remaining.

Good energy conservation practices are a means of compensating for the energy "waste" caused by these increased transformations.

E Measuring energy

Measuring the amount of energy available can be distinguished from measuring the rate at which energy is being used.

1 units of energy (how much)

The different units in which energy is expressed reflect its several forms.

QUESTIONS AND ACTIVITIES

Compare the work input and work output in a simple machine and relate this comparison to the second law of thermodynamics.
(I-14) (I-15)

What are some commonly used units of energy?

a mechanical energy

1) joule

A joule is the metric unit for the amount of mechanical energy required to raise one newton one meter.

2) foot-pound

A foot-pound is the amount of mechanical energy required to raise one pound one foot.

¹²This "wasted" energy is usually thermal or heat energy.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

b heat energy

1) calorie

The calorie is the metric unit for the amount of heat energy needed to raise the temperature of one gram of water one degree Celsius.

How can the chemical energy stored in food be measured?
(Appendix C-4)

2) kilocalorie

The kilocalorie is the metric unit for the amount of heat energy needed to raise the temperature of one kilogram of water one degree Celsius.¹³

The kilocalorie is equivalent to 1,000 calories.

3) British Thermal Unit (BTU)

The British Thermal Unit (BTU) is the amount of heat energy needed to raise the temperature of one pound of water one degree Fahrenheit.

c electrical energy

The kilowatt-hour is a metric unit for the amount of electrical energy released when one kilowatt of power is supplied for one hour.

What is the relationship among the various energy units?
(Appendix B-1)

2 units of power (how fast)

Units of power express the rate at which different forms of energy are provided or how fast work is being done. Power is measured in terms of energy per unit of time.

a BTU/hour

One BTU/hour denotes that one BTU of heat energy is provided in one hour.

¹³The kilocalorie is equivalent to the food Calorie.

b horsepower

One horsepower is the power needed to provide 550 foot-pounds of mechanical energy in one second.

c watt

The watt is the standard metric unit of power.¹⁴

The power requirements of electrical appliances are usually expressed in watts.

d kilowatt

The kilowatt is the most frequently expressed metric unit of electrical power.¹⁵

The kilowatt is equivalent to 1,000 watts.

e megawatt

The megawatt is a metric unit of electrical power equivalent to 1,000,000 watts or 1,000 kilowatts.¹⁶

II. ENERGY SOURCES OF THE PAST AND PRESENT

A History of energy use

United States and world energy use has moved from dependence on renewable energy sources to dependence on non-renewable sources.

For background information, refer to the article, "Energy, Technology and the Story of Man," by Melvin Kranzberg, which may be found in the March, 1972 issue of The Science Teacher.

1 a global view

¹⁴1 watt = 1 joule/sec
746 watts = 1 horsepower

¹⁵1 kilowatt is equivalent to 740 foot-pounds per second.

¹⁶The megawatt is often used to indicate the electrical power generating potential of hydroelectric, fossil fuel, and nuclear power plants.

CONCEPTS AND UNDERSTANDINGS

a primitive societies

Food gathering societies depended directly on the sun for heat, light, and the chemical energy stored by green plants through photosynthesis.

Hunting societies obtained more concentrated energy in the protein of animals, reducing the time spent on eating.

The discovery of fire provided a new source of heat and light from the burning of wood, making possible the eventual forging of weapons and tools.

Early humans required about 2000 kilocalories per day for their energy needs.

b early civilizations

The rise of agriculture brought with it the more efficient use of solar energy for crop production and the domestication of animals for food and sources of power.

The horizontal waterwheel was invented by the first century B.C. and could produce .3 kilowatts of power. Water power was used by the Egyptians, Greeks, and Romans for irrigation and the grinding of grain.¹⁷

The power of human muscle, given greater mechanical advantage through the use of tools, continued to be the predominant energy source.

The "agricultural revolution" increased daily per capita energy use, including food consumption, to 12000 kilocalories.

c middle ages

Few improvements in energy supply and efficiency were observed before the Renaissance.

QUESTIONS AND ACTIVITIES

What were some of the energy sources and technological developments that influenced human lifestyles prior to the Middle Ages? (I-16)

What were the energy sources and devices which contributed to the "power revolution" of the Middle Ages?

¹⁷ Later, a vertical waterwheel capable of developing 2 kilowatts of power was invented.

CONCEPTS AND UNDERSTANDINGS

Advances in waterwheel construction and the introduction of the windmill to Europe in the twelfth century increased manufacturing and stimulated the growth of towns and commerce.

Mechanical power continued to be provided mainly by human and animal muscle.

Wood remained the primary source of domestic heating and fire for such trades as glassblowing and metallurgy.

d the seventeenth century

As wood supplies became scarcer, Europe began to use coal as a substitute, marking the shift to nonrenewable energy resources.

The need to efficiently drain water from increasing numbers of deep coal mines led to the invention of the first steam engine or pump in 1698. This engine had a low power output of .75 kilowatts or about 1 horsepower.

e the eighteenth century

The advent of the steam engine set the stage in England for the Industrial Revolution.¹⁸

Although rapid developments in energy use occurred in industry, animal power and wood heat continued to be the major energy sources for the home and farm.

f the nineteenth century

The use of the steam engine was increased and enhanced by new types of engines.¹⁹

QUESTIONS AND ACTIVITIES

Compare the energy sources used predominantly in Colonial times to those used today. (I-17)

What were the effects of changing energy sources on technology during the Industrial Revolution and vice versa? For background information, refer to the article, "Energy, Engines, and the Giant Step of the Industrial Revolution: A Reader," from Energy, Engines and the Industrial Revolution, Grades 8-9. United States Department of Energy/National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C. 20009, October, 1977.

¹⁸ Thomas Newcomen increased the size of the steam engine. James Watt adapted and applied the steam engine for use in the textile industry in 1776.

¹⁹ With increased coal for both iron and steam production, the age of mechanization began.

CONCEPTS AND UNDERSTANDINGS

The invention of the battery and generator set the stage for the coming electrical age.

The Industrial Revolution spread throughout Europe and the American continent.

At mid-century, the daily per capita energy consumption in nations undergoing industrialization was 70,000 kilocalories.

2 a national view

the nineteenth century

The nineteenth century found the United States shifting its primary energy sources.

1) coal predominates

By 1885, coal replaced wood as the predominant fuel for industrial steam generation and railway travel.²⁰

2) oil exploitation

The desire for cheaper and more efficient substances for lighting and lubrication led to the exploitation of oil deposits, which people had known of for centuries.

3) commercialization of electricity

The development of electrical generating and distribution systems brought a clean and reliable source of energy to the home.²¹

QUESTIONS AND ACTIVITIES

In American history what have been the trends in the use of animal and inanimate energy sources? (I-18)

What major shift occurred in the use of American energy sources from 1850 to 1900? (I-19)

²⁰Trevithick (1804) and Fulton (1807) applied the concept of the steam engine to rail and water travel. The application of the laws of thermodynamics improved the steam engine's design and encouraged the development of the internal combustion and oil-burning engines. The latter increased agricultural

and industrial productivity through improved machinery.

²¹Thomas A. Edison perfected the light bulb in 1879 and supervised the first electrical power-generating/distribution system in New York City in 1882. In that same year, the first hydroelectric plant began operation.

CONCEPTS AND UNDERSTANDINGS

b the twentieth century

Through the twentieth century, the new energy sources provided for a flourishing economy and an energy intensive society.

1) conditions prior to World War I

From 1900 to 1920, the number of automobiles grew from eight thousand to eight million.

Electrical power generation and consumption was seven times higher in 1917 than it had been in 1900. Electricity was ideally suited for use in factory assembly lines.

2) conditions between the world wars

While total energy use grew more slowly between World Wars I and II, the consumption of electricity continued to double every ten years.

The development of long-distance pipelines in the 1930's finally made possible the use of natural gas for home heating, electricity, and manufacturing.

3) trends subsequent to World War II

Oil replaced coal as the dominant fuel just after World War II. The major petroleum product shifted from kerosene to fuel oil to gasoline to satisfy changing demands.

Nuclear energy, exhibited during World War II, was first used to generate electricity in 1951.

By 1955, dependence on oil and natural gas had increased so much that the U.S. became a net importer of fossil fuels.²²

²² Gas replaced coal as the second most used energy source in 1958.

QUESTIONS AND ACTIVITIES

How has the use of energy sources in the U.S. changed during the twentieth century?

Have students interpret the graph, "Changing Fuel Sources in the United States," found in Energy Transitions in United States History, National Science Teachers Association, Washington, D.C., June, 1979, p. 81.

What technological development led to widespread use of natural gas?

What has been the trend in per capita energy consumption over time? (I-20)

CONCEPTS AND UNDERSTANDINGS

Energy demands and consumption have continued to grow faster than the ability of the U.S. to produce needed supplies. This situation has led to increased dependence upon other nations for fossil fuels and rapidly increasing energy costs.

B Present major sources of energy

1 fossil fuels

Fossil fuels are energy sources believed to have been formed over millions of years from the remains of dead plants and animals. Some fossil fuels are crude oil, coal, and natural gas.

a oil

1) form

Oil is a mixture of chemical compounds containing carbon and hydrogen and formed by the gradual decay of marine life exposed to heat and pressure over tens of millions of years.²³

What are fossil fuels?

How is oil formed? (I-21)

2) location

Oil may be trapped in porous rock or in fine-grained shales. Over one-half of proven oil reserves are located in Middle Eastern countries while the United States holds about 5% of known reserves.²⁴

Where is oil found? Examine maps showing petroleum-producing areas of the United States and the world. (Appendix C-6)

3) exploration

Oil tends to collect in traps where nonporous rock layers hold it within adjacent porous rock formations. These oil concentrations may be found both on land and under the sea.

What are some added problems posed by drilling offshore?

Drilling is the method by which oil is brought to the surface.²⁵

²³Such compounds are called hydrocarbons.

²⁴States with substantial petroleum

supplies include Pennsylvania, West Virginia, Kentucky, Illinois, Indiana, Kansas, Oklahoma, Texas and Louisiana.

QUESTIONS AND ACTIVITIES

Compare the history of energy use in New York State to that of the nation.
(Appendix C-5)

CONCEPTS AND UNDERSTANDINGS

Only a small percentage of oil wells drilled will produce sufficient petroleum for commercial use.²⁶

4) production

First natural pressure, then pumps, lift the oil to the surface. A set of valves regulates the oil flow during the process.²⁷ Crude oil is then transported to refineries.

5) refining

Crude oil as found in nature is almost useless. It takes a great deal of processing called refining to make it useful.

Refining involves the physical and chemical separation of crude oil into its many hydrocarbon compounds and the recombining of these substances, with additives, into new petroleum products.²⁸

6) distribution and storage

Both crude oil and the products of refining are distributed by pipelines, barges, and trucks to storage centers.

7) uses of petroleum products

Gasoline is the principal product of oil. It powers our cars, trucks, buses, and motorcycles.

QUESTIONS AND ACTIVITIES

Why might oil companies hesitate to drill for oil in unproven areas?

Why is it important to control the oil's flow from the well?

Describe a specific process by which products can be obtained from crude oil. (I-22)

How are oil and its products transported?

Summarize the major steps involved in obtaining oil products. (I-23)

²⁵Rotary drilling, the most common procedure, involves a bit attached to the end of a length of drill pipe. The bit bores through rock as the pipe is turned and lowered into the earth. Casing is added to the hole to prevent cave-ins.

²⁶Oil wells average 5,000 feet in depth and on the average cost over \$100,000. However, offshore drilling can cost millions.

²⁷Eventually the oil well's production falls to a few barrels per day. The high number of such "stripper" wells makes a significant contribution to domestic oil production.

²⁸Three major refining operations are separation, conversion, and treating.

CONCEPTS AND UNDERSTANDINGS

Aviation gasoline and jet fuels support commercial and military air traffic.

Kerosene is used for cooking, space heating, and jet fuels.

b natural gas

1) form

Natural gas is primarily composed of methane whose molecules each contain one carbon atom bound to four hydrogen atoms.²⁹ It is formed by the same processes which produce oil.

2) location

Gas fields are usually located in the same regions of the United States as oil reserves.³⁰

3) production

After the drilling of a well, casing and valves are installed to contain and regulate the gas flow.³¹

4) storage

To provide for sufficient volumes of natural gas throughout the year, underground reservoirs are used for storage.

5) distribution

Natural gas is first transported by pipelines from wells to centers where impurities and useful chemicals are extracted.

QUESTIONS AND ACTIVITIES

How much heat energy is stored in oil? (I-24)

What products besides gasoline and heating oil are produced from crude oil? (I-25)

What is natural gas and how is it formed?

Where are natural gas deposits located in the U.S.?

What are the sources of natural gas for New York State? (I-26)

How is obtaining gas similar to obtaining oil?

Where is natural gas stored?

What is the main method of distribution of natural gas?

²⁹ Natural gas also contains smaller amounts of liquids such as propane and butane which become gases at slightly higher temperatures.

³⁰ Due to its lower density, natural gas may be trapped in porous rock

above oil or flow into a separate deposit.

³¹ Natural gas' own pressure will help drive it to the surface, especially during the early stages of the well's life.

CONCEPTS AND UNDERSTANDINGS

The "dry gas" which remains is compressed to speed it along the pipelines to distribution centers which serve consumers.³²

Cooling natural gas to about -160°C converts it to a liquid (Liquified Natural Gas) of reduced volume that can be more easily shipped across oceans.³³

6) uses of natural gas

The clean-burning, sulfur-free properties of natural gas make it an ideal fuel for the home and industry.

Natural gas ranks as a major fuel source for the production of electricity.

The by-products of natural gas are used to produce a wide variety of synthetic products, such as rubber, drugs, and dyes.

c coal

1) formation

Approximately 350 million years ago, the earth's climate was warm and moist, producing thick forests and swamps filled with giant mosses, ferns, and primitive trees.

The mud and water in the swamps prevented dead plants from decaying swiftly, allowing them to accumulate and form peat.

As the earth's surface sank, peat beds were covered by mud and sand brought by streams and oceans. The additional pressure and temperatures that resulted

QUESTIONS AND ACTIVITIES

In times of great demand, what problems could result from this distribution method?

Given the properties of oil and natural gas, what are some potential storage and distribution problems? (Appendix C-7)

What are the major uses of natural gas?

What property of natural gas makes it such a popular fuel? (I-26)

How does the formation of coal differ from that of oil or natural gas? (I-27)

³²Some natural gas may be compressed, sealed in pressurized containers, and sold as bottled gas.

³³Some scientists believe that the storage and transportation of

Liquified Natural Gas could lead to accidents that cause catastrophic explosions and fires. Other scientists believe that special design features and safety requirements minimize these risks.

CONCEPTS AND UNDERSTANDINGS

drove off the peat's hydrogen and oxygen, leaving a substance high in carbon called coal.

2) forms

Different temperatures and pressures led to the formation of several types of coal varying in their hardness, heat potential, and sulfur content.

(a) lignite

Lignite is a soft and smoky brownish black coal with a low heat and sulfur content.

(b) bituminous

Bituminous coal, the most abundant form, is harder and darker than lignite and has a high heat content.³⁴

(c) anthracite

Anthracite coal is the hardest and blackest form of coal. It burns cleanly and yields high amounts of heat.

3) location

Coal is located primarily in four large regions of the United States: the Rocky Mountains, the Northern Great Plains, the Midwest, and the Eastern Appalachian Mountains.³⁵

Where are the different types of coal found in the United States? (Appendix C-8)

4) production

Coal is mined by two general methods: strip mining and underground mining.

Which states have the greatest potential for coal obtained by underground mining? Strip mining?

³⁴Subbituminous coal is softer and moister.

³⁵Bituminous coal deposits are widespread throughout the U.S. Lignite

is found in the Northern Great Plains while anthracite coal is largely restricted to eastern Pennsylvania.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

(a) strip mining

When coal beds lie close to the earth's surface, the covering of soil and rock, or overburden, can be removed to expose the coal.

The exposed coal is broken up by explosives and scooped into trucks.

(b) underground mining

Coal lying farther below the Earth's surface is removed by shaft, drift, or slope mines.³⁶

What are some of the issues involved in strip mining and underground mining? (I-29)

5) storage

The bulk and weight of coal usually cause it to be stored in the open air, although such exposure will eventually cause deterioration of softer forms such as subbituminous and lignite.

6) distribution

Coal coming from the mines is first transported to a preparation plant where it is purified, washed, dried, and sorted according to size.

How does coal get from the mine to where it is used?

Following plant processing, coal is most commonly placed in open-topped railroad cars called gondolas and shipped to buyers.³⁷

Some coal may also be mixed with water to form a slurry that can be sent through pipelines.

³⁶ Shaft mines reach deep coal deposits by a vertical hole down to the coal, and horizontal passages through the coal seams. Elevators transport miners, equipment, and coal between the deposits and the surface.

Drift mines reach coal beds in hillsides by an entrance where the coal is exposed and then tunnels back into the

hill through the deposit. Electric locomotives pull cars carrying men and equipment in and out of mines.

Slope mines as their name suggests, reach coal beds in hilly regions by means of sloping tunnels from the surface to the coal. Transport of men and equipment is similar to that of drift mines, although conveyor belts may bring out the coal.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

7) uses of coal

Coal's primary use is as a fuel source for the production of electricity.

Name some uses of coal. (I-30)

The burning of coal still provides heat for many industrial, commercial, and residential needs.

Coal may be baked in air-tight ovens to produce coke, a substance needed for the manufacture of steel from iron ore.

Coal tar and oil distilled from hot gases formed by roasting coal are used to make many synthetic products such as plastics, dyes, and detergents.

2 hydroelectric power

a form

The kinetic energy of moving water may be used to spin giant turbines that generate electricity.

How can the potential and kinetic energy of water be used to do work? (I-31)

b location

Hydroelectric plants are found on major United States rivers, especially within the states of Washington, California, Oregon, New York, and Arizona.³⁷

Where are hydroelectric facilities concentrated in the United States? (I-32)
(Appendix B-4)

c production

In the construction of a hydroelectric plant, it is first necessary to build a dam which will hold a large reservoir of water at a high elevation.

Explain how the design of a dam contributes to the production of electrical energy. (I-33)

Within the dam are troughs that channel the water from its highest point down to the point where it possesses its maximum kinetic energy. At this lowest level, the water is allowed to strike the blades of a turbine-generator.

³⁷Trucks, barges, and freighter ships also transport lesser amounts of coal.

³⁸In New York State, major hydroelectric plants exist on the St. Lawrence Seaway.

CONCEPTS AND UNDERSTANDINGS

Since mechanical energy is converted into electrical energy in one step, hydroelectric plants are far more efficient than plants relying upon the burning of fossil fuels.

d storage

Collecting and storing water in reservoirs generally provides a constant flow of water through the hydroelectric plant, despite seasonal variations in a river's volume and rate of flow.³⁹

e distribution

Electricity produced at the dam is transmitted to the user by overhead powerlines or underground cables.

f electrical contribution

Hydroelectric power provides approximately 15% of the electricity used in the United States.

3 nuclear power

The nucleus of the atom possesses tremendous amounts of potential energy which can be directed to constructive uses.⁴⁰

a form

Nuclear power plants, like fossil fuel plants, produce electricity from steam-driven turbines. However, the fuel used to produce the steam is a form of uranium and the heat released is due to fission rather than combustion.

QUESTIONS AND ACTIVITIES

What does an area which relies heavily on hydroelectric generation of electricity do during periods of peak demand?

Why is the potential and kinetic energy stored in water better used in the electrical form, rather than the mechanical form in today's society?

How is a nuclear reaction different from a chemical reaction?

³⁹Pumped water storage is a way to increase the production of electricity during periods of peak demand. During the night and early morning, when demand is low, electricity is used to pump water to higher reservoirs above the dam.

This increase in water level will maximize the efficiency of the hydroelectric plant during daylight hours, when demand is high.

⁴⁰Great amounts of energy are produced because, in splitting the nucleus, some of the nuclear matter is

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

1) uranium

Uranium is a radioactive element found in several forms, or isotopes, which vary in mass and stability.

What is the major fuel used to produce nuclear energy?

The scarce, unstable isotope U235, is the one desired for nuclear fuels since it is the only substance in nature that undergoes fission.⁴¹

2) fission

The nucleus of uranium 235, when struck by a neutron, will split into smaller nuclei. This process, known as fission, will also produce more neutrons and liberate a significant amount of heat energy.

How does this fuel produce energy? (I-34)

The neutrons released through fission are then free to strike other uranium 235 atoms, causing them to undergo fission as well. In this way, a chain reaction may be established which will produce tremendous amounts of heat. By controlling the chain reaction the energy can be used to generate electricity.

b location

Uranium ore, a nonrenewable resource is located primarily in the Rocky Mountain states and southern Texas. It is recovered through surface or underground mining.

Where is most of the uranium ore located in the United States? (Appendix C-10)

converted to energy and, according to Einstein's equation, $E = mc^2$, tremendous amounts of energy can be produced when a small amount of matter is converted.

Radioactivity is the emission of alpha particles, beta particles, or gamma rays from the unstable nuclei of radioactive elements.

⁴¹If sufficient fissionable material, which has a precise geometric arrangement, is assembled within a short time and then contained long enough, an uncontrollable chain reaction can result. However, in nuclear power plants, the low concentration of uranium 235 and the presence of control rods regulating the rate of the chain reactions make a bomb-like explosion impossible.

c production

Before the uranium can be used as a fuel in nuclear reactor systems, it must first be enriched and formed into pellets. This is necessary because the scarce isotope Uranium 235 is found mixed in nature with the more abundant, nonfissionable isotope uranium 238.

What is the purpose of the enrichment process?

The entire enrichment process alters the amount of uranium 235 from 1% to 3%. In this condition, pellets contain sufficient fissionable material (U-235) to maintain a controlled chain reaction.⁴²

d electrical production

At the nuclear power plant, uranium pellets are stacked end to end in long metal tubes. Thousands of these "fuel rods" are then precisely arranged in bundles to form the core of the reactor.

Control rods, containing material which absorbs neutrons, are placed between the fuel rods. By varying the number of control rods withdrawn and the degree to which they are withdrawn, the rate of the nuclear chain reaction can be controlled.

What is the function of a control rod?

The heat released from the nuclear reactions eventually converts water to steam which is then used to turn a turbine-generator and produce electricity.⁴³

What energy conversions take place in a nuclear power plant?

⁴²The enrichment process consists of changing approximately one ton of mined ore to three pounds of Uranium oxide (U_3O_8), called "yellowcake." This uranium oxide is next converted to uranium hexafluoride, UF_6 . Various methods are then used to concentrate the uranium 235 in the uranium hexafluoride.

uranium 238, it will pass through the barriers faster and form a gas higher in U-235.

The UF_6 , which is now enriched with uranium 235, is then oxidized to again form uranium oxide U_3O_8 , which is placed in heat resistant fuel pellets.

At gaseous diffusion plants, UF_6 is heated to a gas which is forced through barriers with tiny holes. Since uranium 235 is lighter than

⁴³The presence of water in the core also slows down the neutrons, increasing the probability of fission.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

e storage

Eventually nuclear fuel is used up and the fuel rods need to be replaced. Reprocessing of the rods could isolate usable fuel. The remaining unusable material contains potentially hazardous radioactive substances which have to be kept from the ecosystem for thousands of years. At present, the most favorable plan consists of drying this waste to form a glass-like solid of smaller volume. This material could then be stored in a special, dry, isolated site such as a salt mine or other deep, stable, rock formations.⁴⁴

Why does nuclear waste require special treatment? (I-35)
(Appendix C-11)

4 electricity as a secondary energy source

Because of its versatility, electricity is an integral part of our society; it is used to heat and cool buildings, run machines and appliances, and illuminate space. It is considered a secondary energy source since it must be produced from other energy sources.

Why is electricity a popular energy source? (I-36)

a the power plant

Three major types (based upon the energy source used) of power plants are currently in use in the U.S.

Compare and contrast the three main types of electric generating plants. (I-37)
(Appendix C-12)

1) fuel

Fossil fuels serve as the primary energy source in electrical production. They are burned to produce steam. To a lesser extent, the steam produced by nuclear fission and the energy from moving water (hydroelectric power) are used in electrical production.

How are fossil fuels used to turn a turbine? (I-38)

How is the turbine turned in a nuclear power plant and a hydroelectric power plant?

⁴⁴ Arguments opposed to this method include technological ones. There is evidence indicating that radioactive materials can leak out of glass if it is exposed to water at

high temperatures. Other alternatives to the glass form, such as a ceramic form, are being researched. Political opposition to storage site location exists.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

Energy sources used to produce electricity vary greatly by state and region.

2) generation

An alternating current of electricity is produced when a conductor is moved back and forth through a magnetic field and vice versa.

How can an alternating current of electricity be generated?
(I-39)

In a power plant, steam or moving water turns a turbine which rotates an electromagnet between stationary coils.

3) transmission

Electricity is transmitted from the power station at high voltage through almost exclusively overhead lines to the consuming area and then at lower voltage to individual users.⁴⁵

What are some potential problems with the transmission of electricity?

b efficiency

Using electricity is less energy efficient than using direct conversions with primary fuel sources. (See second law of thermodynamics.)⁴⁶

What are some uses of electricity in the home that could be replaced by other energy sources? (I-40)

Describe the main parts of an electric power plant. (I-41)

Compare the form, location, transportation, storage, distribution, and use of the present major energy resources.
(I-42)

III. ASPECTS OF ENERGY PROBLEMS IN THE UNITED STATES

A widening gap between United States energy demand and supplies threatens our standard of living, social well-being, and national security.

Compare energy demand to energy supply in the U.S. (I-43)

⁴⁵Voltage is increased by transformers for travel over distance because high voltage transmission is more efficient. A second transformer reduces the voltage before it reaches the consumer.

⁴⁶Approximately two-thirds of this potential energy of a primary fuel is lost in converting it into electricity and distributing it to the user.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

What happens to prices when supply and demand fluctuate?
(I-44)

A Patterns of consumption

Although the United States contains nearly 6% of the world's population, Americans consume almost one-third of the world's energy. The patterns of the United States' energy consumption can be made clearer when viewing them by economic sector and by source.⁴⁷

How is energy used in New York State? (Appendix C-3)

1 by sector

a transportation

The transportation sector includes the movement of people and goods by automobile, airplane, railroad, ship, truck, and bus.

This sector accounts for over one-fourth of our annual energy consumption. Almost all of this energy comes from oil.

b residential/commercial

The residential/commercial sector includes the uses for energy in our homes, businesses, hospitals, offices, schools, hotels, and churches. Space and water heating, refrigeration, air conditioning, and cooking are the main processes requiring energy in this sector.

This sector accounts for about three-eighths of our annual energy consumption. Demand by source, in that order of importance, is divided among natural gas, oil, and electricity.

c industrial

The industrial sector involves the use of energy for three important processes; the

⁴⁷The patterns in this section are presented to facilitate comparison. The rates and patterns of use could change.

CONCEPTS AND UNDERSTANDINGS

production of process steam, direct heating, and driving machinery with electricity.

This sector accounts for about three-eighths of our annual energy consumption. In addition to natural gas, oil, and electricity, coal is a significant fuel source in this sector.

2 by source

Fossil fuels, hydropower, and nuclear power are considered to be primary energy sources while the electricity generated by them is viewed as a secondary source.

a primary sources

1) coal

Three-fourths of the coal consumed generates electricity and one-fourth is used in industry.

2) oil

Over one-half of our oil is consumed for transportation. Together, the residential/commercial and industrial sectors consume more than one-third of the oil, leaving one-tenth for electrical generation.

3) natural gas

Residential/commercial and industrial sectors each consumes about two-fifths of the natural gas available. Electrical production uses up most of the remaining supply.

4) nuclear and hydroelectric

Nuclear and hydroelectric plants are designed solely to produce electricity.

b electricity - a secondary source

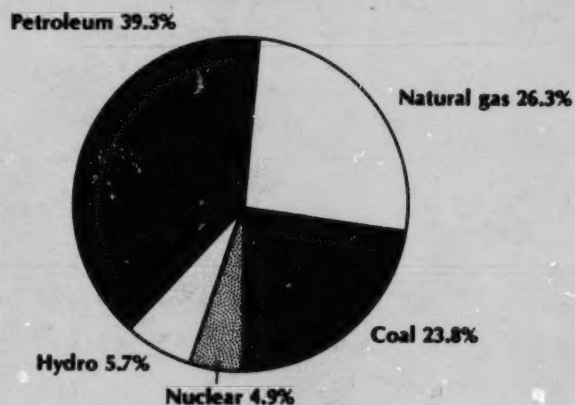
Almost one-half of the electricity generated in the United States comes

QUESTIONS AND ACTIVITIES

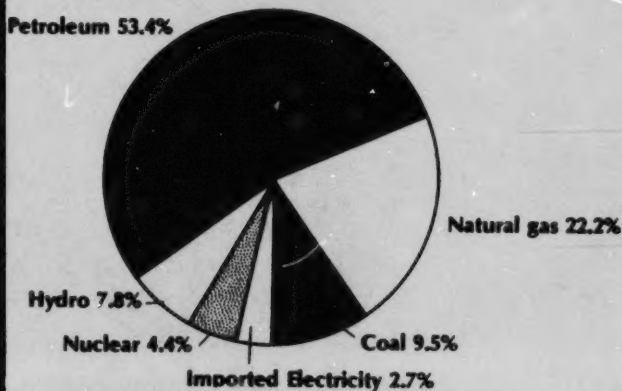
Compare the energy consumption by source for the United States as a whole to that in New York State.*

Energy Consumption by Fuel 1982

United States



New York State



*Data reprinted from New York State Energy Master Plan: Draft Report, August 1983, New York State Energy Office, Two Rockefeller Plaza, Albany, NY 12223.

CONCEPTS AND UNDERSTANDINGS

from burning coal. The remaining electrical power is contributed in fairly equal amounts by oil, natural gas, hydro-power, and nuclear energy.

The residential/commercial sector uses three-fifths of the electricity generated, leaving two-fifths to be consumed by industry. Insignificant amounts of electrical power are used for transportation.

Although 37.5% of the energy from primary sources is used to make electricity, it in turn provides only about 10% of the total energy consumed each year in the United States. This difference indicates that two-thirds of the potential energy is lost while converting it into electricity and distributing it to the various economic sectors. Similar losses occur with other forms of energy conversion such as wood and diesel fuel combustion.

3 implications

Present rates and patterns of energy consumption have serious implications:

a United States dependence on fossil fuels

1) situation

Over nine-tenths of United States energy demands are met by oil, natural gas, and coal, in that order.

However, proven reserves of coal are much greater than those of oil or natural gas.

2) implication

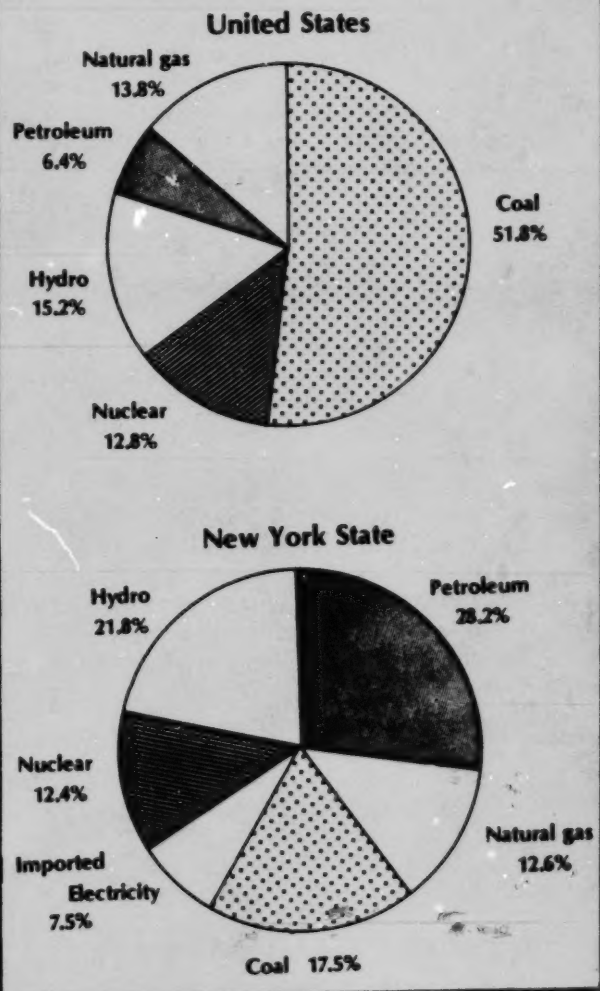
Consequently, our nation is tied to resources whose supplies are limited and diminishing and is most dependent on the fuels which are least abundant.

b United States dependence on imported oil

QUESTIONS AND ACTIVITIES

Compare the energy consumption by electric utilities for the United States and New York State.

Energy Consumption by the Electric Utilities 1982



*Data reprinted from New York State Energy Master Plan: Draft Report, August 1983, New York State Energy Office, Two Rockefeller Plaza, Albany, NY 12223.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

1) situation

Approximately 18% of the United States' energy demand is presently being met with imported oil.

2) implication

Since oil is a critical fuel source for all three economic sectors, substantial changes in the foreign oil supply cause hardships for individual consumers, businesses, and industry alike.

c electrical inefficiency

1) situation

Producing electricity is less energy efficient than using direct conversions with primary fuel sources.

2) implication

With electrical usage growing, increased efforts to conserve the energy now wasted are needed.

Discuss some aspects of oil, coal, gas, nuclear, hydro, and electricity use in the United States that may pose future problems.

d personal contributions to energy conservation

1) situation

Two-fifths of the energy consumed in the United States is for personal transportation and home uses.

2) implication

Consequently, Americans can make many individual contributions to energy conservation which collectively will have a significant impact upon the total energy supply.

B Aspects of increasing energy demand

Energy consumption per capita fluctuates. Decreases have been due to such influences as embargoes, conservation campaigns, recessions, and cost increases. Population in-

Describe ways that an increase in population has led to a need for more energy.

CONCEPTS AND UNDERSTANDINGS

crease, economic upturns, increased supplies, and lowered costs can lead to rises in consumption.

1 increased use of energy-intensive goods

Advertising promotes a greater use of energy-consuming goods in the home (air conditioners, appliances, electric heating systems, and plastics) and in the office (computers and duplicating machines).

2 shifts to energy-intensive means of transport

The construction of an extensive interstate highway system promoted high-speed intercity automobile travel.

Lower fare increases led passengers to air travel and away from more efficient trains and buses.

Government subsidies encouraged a shift in freight transport away from railroads and toward less efficient air and truck travel.

3 economic incentives for higher gas and electrical use

Unit prices for natural gas and electricity were lower for large-volume users, encouraging higher consumption of both sources.⁴⁸

4 economic incentives for industrial expansion

Government tax credits encouraged industries to use more and larger equipment requiring much greater amounts of energy.

QUESTIONS AND ACTIVITIES

What is the relationship between industrial output and per capita energy consumption? (Appendix C-14)

How does energy consumption in your home compare to energy consumption in your parents' homes when they were children? (Appendix C-15)

How have television and advertising increased energy consumption? (I-45)

Which means of transportation in New York State are most used and consume the most energy? (Appendix C-16)

Discuss reductions in energy use through alternative means of transportation.

⁴⁸Some utilities have changed to a flat rate structure which does not encourage higher consumption.

5 increased per capita energy consumption in suburbia

"Suburban sprawl" increased the number of single-family dwellings and the level of commuting, resulting in higher fuel demands.

Why have people left cities for the suburbs?

6 technology spurs consumption

New technologies have contributed to increased energy consumption. Machines now do much of the work formerly done by individuals and many recreational activities use devices that require energy.⁴⁹

What are some recent technological changes that have led to an increase in energy use by you?

C Aspects of decreasing energy supply

Production of fossil fuels in the United States has increased at lower annual rates than those of consumption and has actually decreased in the past several years.

What factors have kept United States energy production low while demand has increased?

Economic, political, and environmental factors and diminishing reserves have led to these decreasing energy supplies.

1 economic and political

a increasing oil production abroad

Exploration for, and production of, oil in the Middle East became far less expensive than in the United States.

Tax credits that permitted oil companies to subtract payments to foreign governments for oil from their United States income taxes also stimulated overseas development.

b government price regulations for natural gas

Interstate price ceilings set by the government discouraged gas production beyond the levels needed within individual producing states.

⁴⁹Calculators now do computations once done by humans. Video games occupy the leisure time of many people. The use of plastics has added to the demand for oil.

c cost of investing

In today's economy, the cost of finding additional energy sources is prohibitive unless the market price of the product is very high.

2 environmental

Environmental problems have led to decreased supplies of various fuels. The environmental problems associated with energy sources include air pollution, land and water pollution, thermal pollution, and nuclear energy hazards.

a air pollution

The burning of fossil fuels, especially coal, causes air pollution. Ironically, attempts to improve air quality have worsened other environmental problems.⁵⁰

What are some environmental concerns that should be considered when using fuels?

Refer to the article, "Behold My Brothers," from The Curious Naturalist, April, 1975, Massachusetts Audubon Society, Lincoln, Massachusetts 01773.

What environmental problems might occur if a shift back to coal in electrical production occurs?

What is acid rain and what makes it difficult to control? (Appendix C-17)

b land and water pollution⁵¹

Such activities as mining for coal, setting up offshore oil and gas drilling platforms, and transporting fuel by ship have increased pollution on land and water.

The construction of dams as well as pipelines can alter the ecology of an area.

Construct a list of possible environmental impacts on land and water quality of coal mining, oil and gas drilling, and transportation.

What are the ecological impacts of building a hydroelectric facility?

c thermal pollution

Both electric power generators and nuclear power plants produce a great

What is thermal pollution? Why is it a problem?

⁵⁰ Clean air standards have helped to shift industrial use of coal to the less available oil and natural gas and reduce fuel economy of automobiles through the introduction of emission standards.

The use of tall stacks on coal-burning plants carries sulfur-

dioxides and nitrogen oxides high into the atmosphere increasing the formation of acid rain.

⁵¹ Delays in Federal projects dealing with oil transport and nuclear power have increased since environmental impact statements have been required.

CONCEPTS AND UNDERSTANDINGS

deal of thermal pollution which can have adverse ecological effects.

d nuclear waste hazard

Nuclear power plants produce hazardous nuclear waste which has to be stored someplace. Resistance to storage and transport of nuclear waste has risen in many localities.⁵²

How might the lack of a place to put nuclear waste affect development of nuclear plants? (See Appendix C-11.)

e health hazards to energy workers

New mine health and safety requirements, while needed, reduced productivity in underground coal mines.⁵³

3 diminishing reserves of present sources

More serious than the political and economic obstacles to increasing domestic production (C,1, p. 35) is the fact that fuel reserves are both diminishing and becoming more difficult to recover.

a fossil fuel reserves

The full-term production of any fossil fuel reserve is thought to follow a bell-shaped curve with an increasing rate of exploitation, culminating at a peak of production, after which the rate declines to zero.⁵⁴

The study of such production cycles has provided estimates of how long fuel reserves will last.

Predict the environmental impact if the "cleaner" fuels were to disappear. (See I-26.)

1) oil

Since 80% of the United States' oil reserves have been estimated to come into production from 1937 to 2003, little domestic oil will be available in the twenty-first century at current rates of consumption.

⁵²Some radioactive waste storage sites have been temporarily closed and the finding of new sites has been slow because of public concern.

⁵³Some of these requirements were aimed at reduction of risk of black lung disease and mine accidents.

⁵⁴First presented by M. King Hubbert in 1956.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

2) natural gas

Because of dwindling reserves, if current natural gas consumption rates continue, natural gas should also be in short supply at the turn of the century.

3) coal

The United States has large reserves of coal. Since it is estimated that 80% of these reserves will be consumed between 2000 and 2300, coal should be readily available as an energy source throughout the twenty-first century.

b hydroelectric potential

Much of the hydroelectric potential in the United States is already being used.

Even if hydroelectric plant capacity can be more than doubled by the year 2000, only about 10% of the nation's electrical demand will be met from this source.

c uranium reserves

Remaining uranium ore reserves are estimated to be sufficient to provide nuclear plants (built until the year 2000) with enough uranium 235 to last throughout their projected lifespans.

Which energy sources provide the greatest opportunity for expanded use? Why?

D Implications of an energy imbalance

The crisis in energy supply has important effects on this nation's economy, standard of living, environment, and international relations.

1 economy

Energy supplies are basic commodities whose costs directly influence the prices of other goods and services.

Skyrocketing energy costs have significantly contributed to economic difficulties.

What effect would an increase in the price of oil have on a family?

CONCEPTS AND UNDERSTANDINGS

Disruptions in the flow of energy can have an immediate impact upon business and industry, lowering productivity and increasing unemployment.⁵⁵

2 standard of living

Although a strong positive relationship exists between per capita wealth and energy consumption throughout the world, several nations enjoy as high a standard of living as the United States while consuming far less energy.⁵⁶

Americans can maintain a reasonably high standard of living while substantially reducing their energy consumption if they will subscribe to effective conservation strategies.

3 environment

Closing the gap between energy demands and supplies by increasing domestic production of traditional sources has serious environmental repercussions.

a fossil fuels

Increased offshore drilling would increase the pollution of the oceans, destroying valuable fisheries and fouling ocean beaches.

Returning to intensive coal production and combustion would scar the landscape, pollute streams, contaminate the air with harmful sulfur dioxide and nitrogen oxides, increase the number of workers exposed to the hazards of coal-mining, and threaten world climatic stability by increasing the level of carbon dioxide in the atmosphere.⁵⁷

QUESTIONS AND ACTIVITIES

Why does the United States have a higher rate of energy consumption per capita than other developed nations?

What are the environmental hazards associated with stepped-up production and use of current major energy resources?

⁵⁵This effect was clearly demonstrated by the Arab Oil Embargo of 1973. Within five months, the gasoline shortage closed thousands of service stations and crippled the automotive and tourist industries.

⁵⁶Examples of such nations are Switzerland, Sweden, Denmark, West

Germany, Norway, and Australia.

⁵⁷Since carbon dioxide helps to prevent the earth's radiant heat from escaping into space, its increase could cause a warming trend with global effects on sea levels, ice distributions, and agriculture.

b nuclear power

Public concern over the accidental release of dangerous radioactive materials and their long-term storage is mounting.

c hydroelectric power

Since many potential hydroelectric sites now only exist within national parks and forests, their development would often conflict with the scenic and recreational value of these areas.

4 international relations

The need for imported oil to close the present energy gap has made the United States dependent on one of the most politically unstable regions of the world, the Middle East.⁵⁸

The United States' foreign policy will continue to reflect the importance of the OPEC (Organization of Petroleum Exporting Countries) cartel's influence on our energy destiny.⁵⁹

High energy consumption in the United States will be viewed with increasing alarm by those underdeveloped nations whose opportunities for industrialization are being eliminated by dwindling resources.

From which regions of the world does the United States get most of its imported oil?

Why should we reduce our reliance on imported oil?

What effects might an oil embargo have on oil exporting and oil importing nations?

Considering current consumption patterns, develop an energy use scenario for the next 25 years in which political, environmental, economic, and technical aspects are included.

IV. APPROACHES TO ENERGY PROBLEMS

To preserve their way of life for themselves and future generations, Americans must restrain the growing demand for energy while shifting to energy supplies that are more plentiful and renewable.

To reach this goal, individual Americans need to make conservation of energy a personal ethic. In addition, as a society we need to recover nonrenewable

What can be done to solve the problem of increasing demand for energy and diminishing supplies of traditional resources?

⁵⁸The 1973 Arab Oil Embargo was imposed in response to planned United States military aid to Israel during the "Yom Kippur" war.

⁵⁹OPEC represents the Organization of Petroleum Exporting Countries.

CONCEPTS AND UNDERSTANDINGS

energy resources more efficiently and to increase reliance on renewable resources.

A Conservation

Conservation implies wise use of energy resources by curtailment, better matching of energy uses to energy sources in order to decrease waste, and improvement in efficiency. It does not mean eliminating consumption altogether.

1 transportation

Transportation accounts for about one-fourth of this country's energy use. Petroleum is the energy source that is used almost exclusively for transportation purposes.

a curtailment

Curtailment means cutting back on the use of energy in transportation through reduced travel or product conveyance.

Planning ahead, making fewer trips, and bicycling or walking when possible all curtail energy use.

Increased cost of fuels causes curtailment.⁶⁰

b matching loads to transport modes

There are significant differences between the efficiencies of various methods of transportation. We often use the least efficient method.⁶¹

QUESTIONS AND ACTIVITIES

What do we mean by conservation of energy?

Approximately what percentage of United States energy consumption is for the conveyance of goods and people?

What is the principal energy resource used to transport goods and people?

What causes people to cut back on their driving?

Do you use your automobile only when necessary? (I-46)

What causes companies to cut back on the shipment of goods?

What does efficiency mean? (I-47)

⁶⁰ Average miles per car per year peaked in 1978 at 10,046 miles and declined during the next two years to 9,135 miles/car. However, it would have to be ascertained that there was the same number of, or

fewer, cars in use in order to conclude that less energy was being used.

⁶¹ Example: Trucks use 67% of freight energy but carry only 25% of the truck load.

CONCEPTS AND UNDERSTANDINGS

More intercity travel by bus and train could reduce energy consumption.

In addition to the use of mass transit, vanpooling and carpooling can significantly decrease consumption of energy in transportation.⁶²

c potential for efficiency improvement

Technical improvements in the auto could result in a 49% increase in efficiency.⁶³

Greater use of diesel engines in trucks and lightweight trucks could result in energy savings.

Improvements in airplane aerodynamics, a modified return to "props," and less weight will make air travel more efficient.

Individuals who observe the 55 mph speed limit, accelerate smoothly, drive at a steady pace, and minimize braking and idling are most efficient.

A well-tuned auto with properly inflated radial tires saves fuel and money.

2 Industry

Industry uses about 39% of the energy in the United States. Conservation efforts in industry have already yielded significant savings.

QUESTIONS AND ACTIVITIES

What is the most efficient means of transporting people and goods? (Appendix C-18)

What is a vanpool? How does it help conserve energy?

Consider various ways of conserving gasoline. (I-48)

How can cars be made to use less fuel? (I-49)

What are some things one should consider when buying a car? (Appendix C-19)

What other types of transport systems can be made more efficient? How? (I-50)

What are some energy-efficient driving habits?

Why do underinflated tires contribute to inefficiency? (I-51)

What are some ways in which industry conserves energy?

⁶²Vanpooling is the most efficient method of urban transport, it is more efficient than mass transit, which is extremely energy intensive to build. If average car passenger density increased from 1.4 to 2.0 a 5% decrease in energy consumption could be realized.

Studies show 75-80% of all commuters could carpool.

⁶³Some areas suggested for research are: aerodynamics, friction reductions, rolling resistance, engine combustion, valve resizing, and electric car engineering.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

a management strategies

Thermostat setback, reduced lighting, fewer leaks, equipment clean up and maintenance can give up to 15% energy savings to industry.⁶⁴

What conservation practices are probably the least expensive ones for industry to use?

b changes in production

Recycling and the use of waste materials decreases energy input.⁶⁵

How much energy can recycling save? (I-52)

Cogeneration, the simultaneous production of electricity and steam heat, normally wasted at power plants but much in demand in industry, could produce significant energy savings.

c technological changes

Waste heat, normally produced by engine exhaust, heat treatments, furnaces, and drying ovens, can be recovered and used further.⁶⁶

What are some technological changes that could reduce energy consumption?

New processes in the steel and aluminum industry save up to two-thirds of energy used in previous processes.⁶⁷

Computerization to monitor and control industrial processes contributes to energy efficiency.

In what ways can computers aid energy conservation in industry?

Technological changes frequently require larger initial investment and therefore may be less attractive to investors.

What factors might prevent the adoption of a new energy-saving technology in an industry?

3 residential, commercial, personal

Residential and commercial uses of energy are about 35% of the total use.

⁶⁴Overall industrial energy savings from 1973-78 were about 22%. In one year, General Motors saved \$900,000 and 18 million kwh by turning off half of its lights in the daytime.

⁶⁵Use of scrap aluminum can decrease aluminum production energy use by up to 95%.

⁶⁶One plant recovered half the heat from an incinerator and used it to produce steam, at a savings of \$120,000.

⁶⁷Replacement of the open-hearth furnace used in steelmaking with the basic oxygen furnace has accomplished these savings.

CONCEPTS AND UNDERSTANDINGS

The commercial portion refers to offices, schools, hospitals, stores, jails and other institutions that serve the economy. Both these and private uses of energy contain many possibilities for energy conservation, especially because they rely on low efficiency electricity and relatively scarce oil and natural gas.

a curtailment

Keeping buildings cooler in winter and warmer in summer conserves energy. These savings may be realized through the design of "tighter", more efficient buildings which are appropriately sited, and by lower thermostat settings in the winter and higher settings in the summer.⁶⁸

b retrofitting

Retrofitting is making improvements in an existing building to reduce heat transfer. Techniques include: installing insulation, caulking around windows, cracks, and doors; installing storm windows, and using insulated drapes or other window treatments.⁶⁹

Furnaces can either be tuned up or replaced with more efficient models or a heat pump can be installed to more efficiency.⁷⁰

c appliances and illumination

Hot water consumption can be decreased by setting back the thermostat, using washing machines and dishwashers to

QUESTIONS AND ACTIVITIES

Refer to the graph in Appendix C-16 and discuss where the greatest savings in energy use for residential and commercial buildings could be realized.

How can a house be made to need to use less heat or cooling? (I-53)

How much saving is accomplished by setting back the thermostat? (Appendix B-6)

Where in a house should a person look for energy "leaks" and problems? (I-54) (Appendix C-20)

How much energy is required for a hot bath or shower? (I-55)

⁶⁸ Heat losses depend on the temperature differential between inside and out; the smaller the temperature difference, the less heat flow there is.

⁶⁹ Most homes could reduce energy consumption by 40-50% through retrofitting.

⁷⁰ A heat pump transfers heat from a cooler region to a warmer one. It works on the same general principle as a refrigerator.

CONCEPTS AND UNDERSTANDINGS

capacity, taking shorter showers, insulating the hot water tank, washing clothes in cold or warm water rather than hot water, or replacing the present hot water heater with a solar or gas water heater.

Consider the EER (Energy Efficiency Rating) label when purchasing a major appliance. This label tells the energy "cost" of operating the appliance per year.⁷¹

Lighting fixtures can be shifted to area of use only, and more efficient fluorescent lights can be substituted for incandescent lamps.

d personal choices

Wherever possible, home production of food through gardens and livestock saves large amounts of energy.⁷²

The choice of hobbies or leisure activities which require little energy expenditure over energy-intensive activities can produce an energy savings.⁷³

4 advantages and disadvantages of conservation

a advantages

Energy saved by conservation is available for use elsewhere without the greater expense of "new" energy.⁷⁴

⁷¹Estimates say this labeling program will save consumers \$111 million per year and 14 million equivalent barrels of oil per year.

⁷²The production, processing, transport, and distribution of food consumes 10 times as much energy as that contained within the food itself.

QUESTIONS AND ACTIVITIES

Which appliances use the most energy? (I-56) (Appendix B-7)

How is an energy efficiency rating label used? (I-57)

What kind of room lighting is more efficient? (I-58)

How does having a home garden save energy?

What kinds of leisure activities are most energy intensive?

What are the positive effects of conservation? Consider the individual, the environment, and the nation.

⁷³Gardening, cross-country skiing, reading, bicycling, and canoeing consume far less energy than snowmobiling, skydiving, or motor-boating.

⁷⁴The energy available by conserving requires no additional capital investment, research, exploration, etc.

CONCEPTS AND UNDERSTANDINGS

Energy conservation improvements save the consumer money.

Methods of conservation are often labor intensive, supplying additional jobs.

Using less energy reduces the environmental effects of energy production, transport, and use.

A reduction in oil consumption strengthens the national security and the economy.

b disadvantages

Personal comfort, convenience, and freedom may be reduced.⁷⁵

Conservation has caused changes in industry and unemployment, especially in the auto industry.

"Tight" buildings may reduce indoor air quality.⁷⁶

Conservation through higher energy prices adversely affects the poor to the greatest extent.

B Energy alternatives

Our energy future provides numerous choices in our use of resources. The possibilities include: enhanced recovery, more efficient processing, and better, more efficient use of non-renewable resources, and a greater dependence on renewable resources.

⁷⁵If rationing or national building temperatures are legislated, certain comforts may be lost.

⁷⁶Radon produced by the decay of radium atoms in rock, brick, soil, and groundwater can collect in the

QUESTIONS AND ACTIVITIES

What might be some negative effects of conservation? Consider the individual, business, and the environment.

What are some of our energy alternatives? (I-59)

lungs and may result in a greater incidence of cancer. CO₂ + CO levels can exceed recommended levels in "tight homes," but proper heat-conserving ventilation can remedy this.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

1 nonrenewable resources

Nonrenewable energy resources are those resources not being replaced during the time span of human history. The increasing costs of energy will make new techniques to recover a greater proportion of these resources economical.

Why is wise use of nonrenewable energy resources important?

a fossil fuels

New technical breakthroughs could allow the United States to recover higher amounts of oil and gas and convert the more abundant coal into synthetic fuels.

1) oil

(a) enhanced recovery techniques

In the life cycle of an oil well, the majority of the oil in a reservoir will remain within rock pores rather than be recovered.⁷⁷

Discuss enhanced recovery techniques and factors which would speed or slow the use of "submarginal" resources. (Appendix C-21)

(1) water flooding

Replacement water may be pumped into the bottom of an oil reservoir, providing pressure to keep the oil flowing toward the producing well.

(2) miscible drive

Liquified propane or carbon dioxide may be injected into the reservoir to mix with the oil and reduce the forces that trap it. A driving fluid can then push the released oil to the well.

⁷⁷We currently recover only 32% of the oil in a deposit. Recovery techniques include thermal recovery. Thick, heavy crude oils may be heated and made to flow to the well by injecting steam under pressure or burning an adjacent portion of oil in place.

CONCEPTS AND UNDERSTANDINGS

(b) oil shale

Large sedimentary rock deposits in the western United States contain solid organic material which can be decomposed by heat into an oil resembling petroleum.⁷⁸ These deposits are called oil shale.

Two approaches to the recovery of shale oil have been proposed:

(1) above ground retorting⁷⁹

Mined oil shale may be crushed and heated in a vertical vessel (retort) to give off gas and crude oil in a vapor state. The crude oil is then condensed into a liquid while the gas is recycled to fuel the vessel.⁸⁰

(2) *in situ* processing

An idea gaining in popularity is to process the shale in place, avoiding the costs of mining, crushing, and waste disposal.⁸¹

⁷⁸The most promising deposit is the Green River Formation, covering 17,000 square miles of Colorado, Utah, and Wyoming. The potential oil yield of their four basins has been estimated at 600 billion barrels, each ton of shale averaging a yield of 25 gallons of oil.

⁷⁹Retorting refers to the separation of the hydrocarbons from the shale minerals. The term is introduced due to its wide usage in oil shale technology.

⁸⁰The spent shale is considerable in

QUESTIONS AND ACTIVITIES

Why is oil shale considered to be a possible energy source? (Appendix C-21)

volume and presents a disposal problem.

⁸¹*In situ* processing involves drilling wells into the deposit, fracturing it to increase permeability, igniting the shale, pumping compressed air into the formation to support combustion and force hot gasses through the rock to convert organic matter into oil, and then recovering the oil formed through other wells.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

2) natural gas

Enhanced recovery techniques for natural gas are designed to make a rock formation more permeable to gas or to locate the most permeable parts of the formation.⁸²

How important are enhanced recovery techniques for natural gas? (Appendix C-21)

(a) rock fracture

Fracturing rock formation with chemical explosives or by pumping in water under high pressure increases the permeability of a gas reservoir.

(b) directional drilling

Permeable reservoirs may be reached by drilling nonvertical wells through natural fractures.

3) coal

Several means of converting coal into cleaner, more convenient, and environmentally acceptable synthetic fuels are being developed. In all such techniques, large amounts of hydrogen must be added to the carbon of coal.⁸³

Why are new technologies for the conversion of coal from a solid to a liquid or a gas being considered?

(a) gasification

Coal may be converted into high heat gas by burning coal in a closed vessel and blowing oxygen and steam through it to produce methane, known as synthesized natural gas.(SNG).⁸⁴

How may methane be produced from coal? (Appendix C-22)

⁸²An additional 250 trillion cubic feet of natural gas might be extracted by enhanced recovery techniques.

conversion processes form molecules known as polycyclic aromatic hydrocarbons (PAHS), many of which are carcinogenic.

⁸³Synthetic fuels are not without problems. Gasifiers require water supplies, which are scarce in arid regions of abundant coal. Strip mining of coal for gasification will threaten land use alternatives. There is evidence that the high temperatures involved in coal

⁸⁴This procedure actually entails several chemical reactions and can be accomplished by a number of gasification processes.

(b) liquefaction

Several complex chemical procedures enable coal to be converted into fuel oil, diesel fuel, and gasoline.⁸⁵

(c) solvent refining

Solvent refining first dissolves coal to remove its ash and sulfur. The purified coal is then reformed as a clean-burning solid of high heat content.

b uranium

The development of breeder nuclear reactors would permit the use of uranium-238 as a fuel, extending the use of uranium ore reserves for thousands of years.

What are some advantages of a breeder reactor over a conventional nuclear reactor? (Appendix C-23)

1) the breeding process

When uranium-235 undergoes fission, it releases several neutrons. One neutron is necessary to maintain the chain reaction, while the others are free to strike uranium-238 which rapidly decays into plutonium-239.⁸⁶

⁸⁵ Much of the liquefaction technology was developed in Germany during the second World War. Three primary procedures are hydrogenation, pyrolysis, and catalytic conversion. In hydrogenation, coal is treated with hydrogen under heat and pressure to form heavy fuel oil and other products. In pyrolysis, coal is heated in the absence of oxygen to produce natural gas, crude oil, and a solid residue known as char through the breakdown and rearrangement of coal molecules. In catalytic conversion, pulverized coal is turned into a gaseous mixture of carbon monoxide and hydrogen. This gas is passed over metal catalysts

such as cobalt and iron to change it into diesel fuel and gasoline.

⁸⁶ This process occurs to some extent in present-day, light water reactors, although the plutonium is seldom recovered.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

Plutonium-239 is a long-lived radioactive material that can serve as a nuclear reactor fuel. In breeder reactors, four plutonium-239 nuclei would be formed for every three uranium-235 nuclei destroyed. Consequently, more fuel would be created than used up.⁸⁷

2) the breeder reactor

The breeder reactor would operate much like a conventional reactor, although specific sites for plutonium formation would exist and liquid sodium would replace water as a heat transfer fluid.

As in a conventional reactor, the heat released by the nuclear reactions can be used to generate electricity.

3) current problems

Breeder reactors would create the same radioactive wastes about which there is much public concern.

Large numbers of breeder reactors would produce several thousand tons of plutonium each year. Since plutonium is easily purified for use in nuclear bombs, sufficient security to prevent its deliberate misuse or theft would be required.

As a consequence of these issues, the future contribution of breeder technology to United States energy production is most uncertain.

Explain what the present status of breeder reactor production is in the United States. (I-59)

⁸⁷ An advanced breeder would create enough fuel for itself and another similar reactor in 10 to 15 years.

2 renewable resources

Renewable resources are recycled by natural processes within a relatively brief span of time. Fresh water, wind, sunshine, and plants are examples of resources that replace themselves over short periods of time.

a solar energy

The tremendous potential of the Sun as an abundant, nonpolluting energy source is stimulating development of existing and new technologies to capture solar energy and put it to a variety of uses.

What is solar energy?

1) form

Solar energy is in the form of electromagnetic radiation produced by nuclear fusion reactions occurring deep within the sun.⁸⁸

At the Sun's surface, most of the radiation exists as visible light, infrared, and ultraviolet waves. Since this energy is radiated in all directions, the Earth obtains only a small portion of the Sun's total radiant energy.⁸⁹

Less than one-half of the solar radiation arriving at the Earth's outer atmosphere reaches the Earth's surface. The rest is reflected or absorbed by the Earth's atmosphere.⁹⁰

How much solar heat comes from the Sun? (I-60)

⁸⁸In each fusion reaction, four hydrogen nuclei are fused into one helium nucleus. Four million tons of hydrogen are converted to helium yielding an output of 6×10^{23} horsepower.

calories per minute per square centimeter (or 1360 watts per square meter). This latter value is known as the solar constant.

⁸⁹While the radiant energy released at the Sun's surface is about 100,000 calories per minute per square centimeter, the top of the Earth's atmosphere receives only about 1.94

⁹⁰The average amount of radiation absorbed by the Earth's surface during the year is about .23 per centimeter per minute, or 160 watts per square meter, or 13% of the original energy reaching the planet.

CONCEPTS AND UNDERSTANDINGS

While the total amount of solar radiation reaching the Earth provides thousands of times more energy than the world demands, such radiation is spread out and varies greatly with time of day, season of the year, and geographical location. Techniques for collecting and using solar energy must take these factors into account.

2) use

Solar radiant energy can be converted into useful forms of energy which meet an increasing percentage of our needs.⁹¹

(a) heating

The Sun's infrared radiation may be used to heat the air and water of homes, offices and factories.

Solar heating may be either passive or active.

(1) passive heating

Homes and commercial buildings may be architecturally designed for efficient collection and storage of solar energy without elaborate equipment.

Such factors such as build-
materials, the orienta-
tion to the Sun, location
of windows, roof overhang,
and landscaping are impor-
tant to passive heating
designs.

QUESTIONS AND ACTIVITIES

What characteristics of the nature of solar radiation affect its capability to be used as an energy source?

What are some uses to which solar energy can be put? (I-61)

How can the Sun's radiation be used to heat buildings? (I-62)

What is the difference between passive and active solar heating?

What are some factors to consider in making use of passive heating? (I-63) (Appendix C-24)

What are some examples of passive solar systems? (Appendix B-8)

⁹¹The direct use of solar energy is not new. In addition to agriculture, humans have relied upon the sun for desalinization, cooking, and space and water heating for many years. However, the development of cheaper

fuel sources in the last two centuries has prevented widespread adoption of solar technologies to meet these needs.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

(2) active heating

An active solar heating system contains collectors, a heat storage system, and an externally powered heat transport system:

Solar collectors. Solar collectors are designed to face the Sun at right angles, absorb its radiation, and transfer the heat produced to air or water.⁹²

heat storage systems. Heat produced by solar collectors is transported to a storage unit that can hold and provide energy for nights and cloudy days.⁹³

heat transport systems. The heat obtained by collectors and that which is stored may be circulated by conventional hot air or hot water systems requiring electric fans or pumps.

What are the basic components of an active solar heating system? (Appendix C-25)

What are some ways that solar energy can be stored? (I-64)

(b) cooling

Solar heat may be used to vaporize liquids that absorb and transfer heat from buildings, making its use in air conditioning very attractive in warm and sunny regions of the United States.

⁹²Flat plate collectors are insulated boxes containing hard absorbing surfaces covered by transparent plates of glass or plastic. Air or water is circulated near or through the absorbing surface to collect heat.

⁹³Typical storage materials include: rocks, cement, water, Glauber's salt (sodium thiosulphate), and sand.

CONCEPTS AND UNDERSTANDINGS

(c) electricity

Solar energy may be converted into electricity by three promising techniques:

(1) thermal energy conversion

A field of large mirrors may focus and concentrate sunlight onto a centrally-located receiver where the radiant heat energy is used to produce steam that can drive turbine-generators.

(2) photovoltaic conversion

Solar cells made of silicon, cadmium sulfide, and other materials contain atoms whose electrons can be knocked loose by sunlight. These electrons can be made to flow as an electrical current.

(3) ocean thermal energy conversion

Solar energy warms the surface water of oceans to temperatures considerably higher than those beneath the sea.

3) potential

While the contributions of solar technologies to the total United States energy demand may be only a few percent by the year 2000, it is expected that solar heat and electricity will be major sources by the middle of the century.

QUESTIONS AND ACTIVITIES

What are some ways in which solar energy may be converted to electricity? (I-65)

Compare thermal energy conversion using solar energy to the fossil fuel and nuclear electric power plants. Use several factors such as thermal efficiency, capital costs, and environmental impact.

On what principle is ocean thermal energy conversion based?

What are some of the advantages and some of the problems related to the use of solar energy? (Appendix C-26)

In what regions of the country might solar home heating be most feasible? (Appendix B-10)

CONCEPTS AND UNDERSTANDINGS

A fundamental challenge is to bring already well-developed solar technologies within the economic reach of all Americans.

b biofuels

There are two kinds of biofuels: fuel from plants grown for their energy content and fuel from "left-overs" in forestry, agriculture, or solid waste produced by humans.

1) fuel from plants

(a) form

Photosynthesis is the biochemical process by which green plants convert solar energy into stored chemical energy.⁹⁴

The production of biomass, or the plant material itself, is an inefficient process.⁹⁵

(b) use

Several fast-growing crops show promise as biomass energy sources. These could be "farmed" and harvested.⁹⁶

Wood burning to provide heat is a practice increasing in popularity as fossil fuels become more expensive.⁹⁷

QUESTIONS AND ACTIVITIES

What are biofuels?

What are the two basic classes of biofuels?

How do green plants convert sunlight to chemical energy? (I-66)

What types of biomass are burned to produce heat? Discuss some of the problems caused by the extensive use of wood as a fuel for homes. (Appendix C-27)

⁹⁴The chemical equation associated with photosynthesis is:

light

$$6\text{CO}_2 + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$$

in the presence of chlorophyll, the green pigment of plants. The glucose is then used by plants for energy and building plant tissues.

⁹⁵Efficiency of photosynthesis rarely exceeds 3%. Most light striking the plant is not converted into chemical energy, but is reflected or dissipated into the atmosphere.

⁹⁶These include kelp and other algae, water hyacinths, poplar, sycamore, and red alder. Others such as the guayule, euphorbia bush, and peanut produce hydrocarbons in addition to carbohydrates.

⁹⁷Although the number of homes heated by wood is expected to increase, other factors such as cost, insurance, and local ordinances may affect this increase.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

(c) potential

Biomass can be converted to several useful energy forms: chemical energy in the form of methane, methanol, ethanol, oil and charcoal, and heat energy from the reaction of combustion.

2) fuel from wastes

(a) form

The organic portions of urban waste, municipal sewage sludge, industrial waste, and agricultural forestry residues are potentially useful fuels.

How much of a problem is the disposal of waste in the United States? (I-67)

(b) use

Solid wastes may be burned or converted into fuels through processes requiring heat (thermal systems) or by bacterial action (biological systems).

What are the methods by which waste may be converted to usable energy resources? (Appendix B-11)

(1) thermal

Waste may be burned to generate steam for space heating or electricity.⁹⁸

Heating waste without oxygen is called pyrolysis and causes it to decompose into natural gas and oil.⁹⁹

⁹⁸A pioneer plant in St. Louis, run by the Union Electric Company, burned suspended shredded waste to produce electricity. There are now several more around the country. Oceanside, New York has a water-wall incinerator for waste burning and electricity production.

⁹⁹The gas and oil produced in this manner have lower heat content than natural fuels.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

(2) biological

Bacteria may produce methane gas by digesting the organic materials in garbage, sewage, and manure in the absence of oxygen.

Farm/agricultural residues may be fermented to alcohol in the presence of oxygen.

(c) potential

Energy from biomass offers a diversified approach to the two problems of eliminating waste and producing energy. Increased use of biomass could reduce the size of landfills. If used as a replacement for fossil fuel, biomass will reduce sulfur emissions. Careful use of biomass energy will be necessary in order to insure that other needs are met, such as fertilization of the soil, use of wood for other purposes, and sufficient food supplies.¹⁰⁰

What are some of the advantages and disadvantages of using biomass for energy?

c wind energy

The uneven heating of the Earth's surface by the Sun produces differences in atmospheric air pressure that develop local and planetary winds.

Why is wind considered a form of solar energy?

1) form

The power output of wind generators depends on wind speed, diameter of the blades, and efficiency of the apparatus.¹⁰¹

¹⁰⁰There are few plans to divert biomass now used in food or forest product production; rather, the focus is on the utilization of waste and residue.

¹⁰¹Large windmills built by the federal government and private concerns produce from 100 Kw and have rotors up to 300 ft. in diameter.

CONCEPTS AND UNDERSTANDINGS

Siting of a windmill is important since wind speed is an important factor in energy production.¹⁰²

2) use

Theoretically, wind generators could reach efficiencies of up to 59% but actual efficiencies reach only 45%. Windmills use the mechanical energy of their rotating blades to do mechanical work (pumping water) or to produce electrical or heat energy.

3) potential

The advantages of windpower are: the source is free and renewable, there is little or no adverse environmental effect, and it is economically attractive in areas where it is available and the fuel costs are high.¹⁰³

The erratic nature of wind and the cost of storage of energy if steady energy supply is needed are disadvantages.

d nuclear fusion

If several important technical problems are solved, nuclear fusion could offer a safe, inexhaustible, and environmentally sound source of energy in the twenty-first century.¹⁰⁴

QUESTIONS AND ACTIVITIES

What are some of the factors to consider in deciding whether wind energy would be useful in a particular location? (I-68)

To what forms of energy can wind energy be converted?

Is there enough wind in your area to produce electricity? (I-69)

What are the advantages and disadvantages of using wind energy?

¹⁰²Wind power generators operate at their rated capacities only when the wind is blowing at the optimum velocity for the design of the machine.

¹⁰³Windmills produce noise, interfere with television and radio reception, and are considered aesthetically unattractive by some.

¹⁰⁴Fusion reactions provide the Sun with its enormous amounts of radiation and are the basis for the hydrogen bomb.

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

1) form

Nuclear fusion plants, like fission plants, could produce electricity from steam-driven turbine-generators. However, the fuels used would be far more abundant than uranium and the heat released would be due to the fusing of small atomic nuclei rather than the splitting of large unstable atoms.

Deuterium and tritium, which are heavier forms of the element hydrogen, are the fuel sources for the fusion process.¹⁰⁵

If a mixture of deuterium and tritium can be brought to a temperature of 50 to 100 million degrees celsius, and held together long enough, a "plasma" of charged nuclei may fuse to form atoms of helium and free neutrons.¹⁰⁶

When nuclei fuse and release neutrons, there is a slight loss of mass which is converted into large amounts of energy, readily changed into heat. Such heat could be used to produce steam for electricity.

Compare the way electricity is generated in fusion plants and in conventional nuclear fission plants.

How do nuclear fission and fusion reactions differ?

2) use

Nuclear fusion plants would be established for the purpose of producing electricity.

¹⁰⁵Deuterium combines with oxygen to make relatively rare molecules of "heavy water." However, since water is so abundant, the Earth's oceans, lakes, and rivers contain 10 trillion tons of deuterium. Tritium can be produced within a reactor from lithium, a light metallic element with sufficient known reserves to last tens of thousands of years.

¹⁰⁶Other reactions involving the fusion of only deuterium nuclei exist but reacting temperatures of 500 million °C make their replication less likely.

CONCEPTS AND UNDERSTANDINGS

3) potential

Fusion could provide us with energy for hundreds of thousands of years if certain technological problems are solved. The present elusive task is to confine the deuterium-tritium mixture at sufficient density, and make it hot enough to cause the reaction to occur and become continuous.

If achieved, fusion reactors are an improvement upon fission and breeder reactors in several important ways: safety, supply (inexhaustible), environmental impact.

(a) safety

Tritium, the only radioactive element common to fusion reactors, is short-lived (half-life = 12 years) and less dangerous than fission products.

The absence of large amounts of radioactive wastes prevents the storage and national security problems associated with fission reactors.

(b) inexhaustibility

Fusion reactors use forms of hydrogen that are more abundant than fission-type fuel and estimates are that the supply will last indefinitely.

(c) environmental impact

The production of fusion fuels in the amounts required should cause very slight environmental disruptions.

QUESTIONS AND ACTIVITIES

What are some advantages and disadvantages to continuing research in fusion?
(Appendix C-28)

CONCEPTS AND UNDERSTANDINGS

Continued governmental support for fusion research and development may make this process the chief source of electric power in the United States by the middle of the twenty-first century.

e geothermal

Geothermal energy is the heat energy produced within the Earth's crust. Today it is being used in several countries to provide for some energy needs.

1) form

Geothermal energy is the natural heat of the Earth produced by the radioactive decay of elements in the Earth's core.

While most geothermal heat in the Earth is too deep and spread out to be economically recovered, there exist concentrated pockets of heat formed by pools of molten rock brought within a few miles of the Earth's surface. These "hot spots" contain energy stored in solid rock or in water and steam that fill the cracks and pores in the rock.

Most geothermal reservoirs contain water under such high pressures that it exists as a liquid even at temperatures far above its normal boiling point.¹⁰⁷

¹⁰⁷When the liquid from such hot water systems reaches the surface, as in natural hot springs or geysers, some of the water boils and a mixture of hot water and steam is produced.

QUESTIONS AND ACTIVITIES

What is geothermal energy?
(I-70)

What produces the heat for geothermal energy?

CONCEPTS AND UNDERSTANDINGS

A few geothermal reservoirs produce superheated steam with no water at the surface. These vapor-dominated systems are the most attractive for the production of electricity.¹⁰⁸

2) use

There are two basic uses of geothermal energy. The first consists of heating buildings by pumping steam and hot water to them.¹⁰⁹

The second use of geothermal energy involves using the steam to produce electricity.¹¹⁰

3) potential

While it is thought that the world's geothermal reserves may be equal in heat content to its coal deposits, only a small fraction of the heat in any well can be extracted and converted into electricity.

QUESTIONS AND ACTIVITIES

How can hot rock be used to produce steam? (I-71)

For what purpose can steam produced from hot rock be used?

Where are the most probable development sites of geothermal energy in the United States? (Appendix B-14)

¹⁰⁸ Worldwide geothermal reservoirs are located near zones of volcanic activity and mountain building along the margins of the Earth's crustal plates.

Large hot-water geothermal fields are found in New Zealand, Mexico, Japan, California, and the Yellowstone region of Wyoming.

Vapor-dominated or "drystream" geothermal reservoirs are known to exist at Larderello in Italy and in the geysers in California.

¹⁰⁹ Buildings will have to be near a geothermal site in order to be heated by geothermal energy. Geothermal water is being used in Iceland and Oregon for heating houses and greenhouses.

¹¹⁰ To obtain geothermal energy, wells are drilled into the reservoir and the steam extracted is used to turn turbines producing electricity.

Vapor-dominated systems presently supply most of the electrical power generated by geothermal plants.

Since geothermal steam is under lower temperatures and pressures than fossil fuel-produced steam, geothermal power plants have a lower efficiency compared to fossil or nuclear plants.

CONCEPTS AND UNDERSTANDINGS

Owing to the requirement that the steam be used directly for electrical production at the well site, geothermal energy will continue to be of more local than national value.

Although environmental problems are small compared to other sources, the following may be considered potential drawbacks: noise from escaping steam, location of unsightly plants in scenic areas, possible subsidence as a result of withdrawing underground water, and the release of undesirable minerals in the area surrounding the plant.¹¹¹

f tidal power

The use of tides to generate electricity is too limited to be of more than local significance.

1) form

Tides are a result of the gravitational attraction of the Moon upon the oceans of the Earth.

The Earth's daily rotation and the Moon's monthly revolution determine the time and strength of high and low tides.

2) use

The movement of seawater as a tide rises and falls may be used to turn large turbines to generate electricity.¹¹²

QUESTIONS AND ACTIVITIES

What are tides?

Compare the generation of electricity by tides and by hydropower.

¹¹¹Many geothermal sites are located in scenic areas such as Yellowstone National Park.

¹¹²Tides were used to mill grain for hundreds of years. The first commercial tidal power station was constructed in 1966 in France and has a capacity of 240 megawatts.

CONCEPTS AND UNDERSTANDINGS

3) potential

Tidal power is limited to a few bays and estuaries where the ocean basin is narrow and deep enough to insure very high tides.¹¹³

Limited sites and the variability of tidal power will probably prevent it from becoming a major source of electricity in the future.

g fuel cells

It is inefficient to burn fossil fuels to produce heat energy which is then converted to mechanical energy for turning an electrical generator.¹¹⁴ The fuel cell is a device that bypasses the heat step and converts chemical energy directly to electrical energy, with expected efficiencies of 80% or more.

1) form

Fuel cells operate on the battery principle with one important difference; fuel supply is continuous and does not need recharging. The simplest fuel cells use hydrogen and oxygen which are combined to produce H_2O .¹¹⁵

¹¹³The Bay of Fundy's 30,000 megawatt potential has been studied for half a century by the United States and Canada.

¹¹⁴Present fossil fuel electric plants are 30-40% efficient.

¹¹⁵The reaction is the reverse of the electrolysis of water. Oxygen is fed into the positive electrode. The hydrogen is fed into the negative electrode, where in the presence of a catalyst it loses an electron, forming a hydrogen ion

QUESTIONS AND ACTIVITIES

Describe the characteristics of an ideal location for tidal power. (I-72)

Use the second law of thermodynamics to explain why a fuel cell is more efficient than fossil fuels in the production of electricity.

How is electricity produced in a fuel cell? (I-73)

(H^+). The ion moves through the electrolyte while the electron travels in an external circuit. At the positive electrode, two electrons are picked up by an oxygen atom forming O^{--} . This ion combines with two H^+ ions to form H_2O .

CONCEPTS AND UNDERSTANDINGS

QUESTIONS AND ACTIVITIES

2) use

Fuel cells have been used in space on the Apollo and Gemini missions to produce electricity.

3) potential

Fuel cells have the advantage, unlike conventional electric plants, of maintaining constant efficiency over a range of loads.¹¹⁶

What are some of the advantages and disadvantages of using fuel cells?

The fuel cell produces only water and carbon dioxide as "pollutants," and operates quietly, making location close to use possible, thus lowering transmission cost.

Fuel cells are currently expensive because of the cost of the catalysts and electrolytes. Platinum is often used as a catalyst and phosphoric acid as the electrolyte.

¹¹⁶Fossil fuel plants are most efficient when they are producing large amounts of electricity, but efficiency drops when generation drops. Efficiency of fuel cells does not change with output because the amount of fuel, hydrogen, is controlled.

APPENDIX A — LEARNING ACTIVITIES

I-1. An Energy Definition

(1, 2, 17)*

Have students arrive at a definition of energy by studying a series of pictures or transparencies demonstrating some effects of energy use in the past. Examples could include:

- Caveman cooking over a fire
- Waterwheel grinding wheat
- Windmill
- Sailboat
- Wagon being drawn by horses
- Steamboat
- Farmer plowing a field with a horse and plow

Students should then demonstrate what energy is, using present-day ideas and activities. Based upon all of the ideas presented in class as to an energy definition, students should revise their definitions to recognize that energy is simply defined as the ability to do work.

I-2. Potential and Kinetic Energy

(1, 2, 14)

A swinging pendulum can be used to demonstrate the relationship between kinetic and potential energy. Materials needed are: a pendulum bob, thread, ringstand, and ring.

Have students suspend a simple pendulum from a ring attached to a ring stand as illustrated in the diagram. (Any object attached to a string can serve as a pendulum bob.)

Students first hold pendulum at position A and release it so that it falls freely.

Observe back and forth motion. Have them describe the back and forth motion, and describe what is happening in terms of kinetic and potential energy.

The students' hands do work in placing the pendulum in position A where it acquires potential energy.



Upon release as the pendulum moves toward B, its potential energy is converted to kinetic energy which is greatest at position B. As the pendulum passes from B to C, the energy is being changed from kinetic to potential energy until potential energy peaks at C. The same pattern repeats itself with each back and forth motion.

*Processes listed on page 5.

Have students attempt to explain why the pendulum eventually stops. (Some energy is lost to the surrounding air in each swing due to friction between molecules in the air and the pendulum. All of the energy is eventually converted to heat energy in the surrounding air.)*

I-3. Potential and Kinetic Energy Relationships (1, 2, 17)

To further develop the concept of potential and kinetic energy, give students a list of actions/activities/conditions. They should describe how potential and kinetic energy are involved, including any changes between the two, in each instance.

- Hitting a tennis ball with the racquet
- A playground swing in motion
- Storing water in a reservoir for water supply or production of electricity
- Operation of a pile driver
- Stretched rubber band
- Use of a battery in a watch or clock
- Ski lift in operation
- Eating food
- Using a bow and arrow
- Air pressure in inflated automobile tires

I-4. Mechanical Energy to Heat Energy (1, 5, 14)

Energy conversions occur continuously. Mechanical energy can be converted to heat energy by the simple action of shaking something. The materials required are a beaker, .5 kilogram of BB's (lead shot), a thermometer, and a plastic container with lid.

Have students carefully pour .5 kilogram of lead shot into a beaker and measure and record the temperature of the lead shot. (Instruct students to place the thermometer well into the lead shot). Pour the lead shot into the plastic container and, holding down the lid, shake the container vigorously 30 to 50 times. Again measure and record the temperature of the lead shot.

Students should note an increase in temperature following the shaking of the lead shot.

I-5. Energy from the Sun (1, 9, 16)

Have students use a radiometer to observe the ability of light energy to do work. Students should put the radiometer near a bright light source (a window on a sunny day is satisfactory). They should cover the radiometer, remove the box, and observe what happens.

Students should note that, at first, the paddle wheels in the radiometer are either not moving or moving very slowly. However, after a short period of time the paddle wheels should move very rapidly.

This experiment demonstrates the conversion of light energy to the mechanical energy of the moving paddle wheel.

*Reprinted with permission from: Energy: Pennsylvania's Energy Curriculum for the Middle Grades, Pennsylvania Department of Education, Harrisburg, PA 17126, p. 37.

I-6. Heat Transfer

(5, 6, 14)

In order to observe the direction of heat flow from warmer objects to cooler objects, have students pour some hot water into a large beaker (such as a 250 ml beaker) and some cold water into a smaller beaker (such as a 50 ml beaker). Measure and record the temperature of the water in each beaker, and then put the smaller beaker into the larger beaker. After about 10 minutes measure and record the temperature of the water in each beaker.

Students should discover that the warmer water probably cooled and the cooler water definitely became warmer.

I-7. Chemical Energy (Teacher Demonstration)

(1, 6, 14)

The construction of a wet cell battery shows how chemical energy can be used to produce electricity. Materials needed are:

- one 1" x 5" copper strip
- one 1" x 5" zinc strip
- 12 inches of insulated copper bell wire
- 100 ml of dilute sulfuric acid (Prepare dilute solution by slowly adding one part acid to 10 parts of water.)
- beaker
- knife

(Caution: Safety glasses should be worn during the activity.)

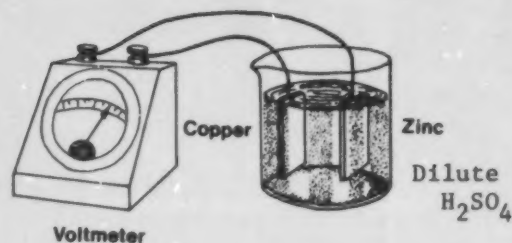
Before this teacher demonstration of the wet cell battery, students should be briefed on the safety procedures involved in the use of caustic materials. Carefully pour acid into the beaker. Use the knife to strip the wire four inches at one end, one inch at the other end.

Wrap the 4-inch bared wire end around the top of the copper strip and place the other end of the copper strip in the beaker. Next place the zinc strip in the beaker taking care that it does not touch the copper strip. Observations of the two metal strips are made. Then the 1-inch bared wire is touched to the top of the zinc strip and held for a few minutes while observations are made.

The students should observe that, before the two strips are connected, bubbles appear around the zinc strip, but not the copper strip. Only when the zinc strip is connected to the copper strip, do bubbles also appear on it. The connection has allowed electrons to flow from zinc, a more reactive metal, to copper. When the electrons come into contact with the acid ions around the copper strip, bubbles of hydrogen gas are released at the surface of the strip.

The conclusion can be made that the presence of bubbles around the copper indicates the generation of electricity. Chemical energy has been converted to electrical energy.

As an alternative or additional activity, put both the copper and zinc strips into the acid and connect to a voltmeter. (See diagram.)



I-8. Chemical Energy in a Match

(1, 2, 14)

Have students observe the production of heat and light energy from chemical energy by striking a match. Students should realize that a match head contains chemicals with stored energy which can be released by the heat of friction (striking the match) to produce new chemical substances as well as heat and light energy.

I-9. Chemical Energy in Magnesium (Teacher Demonstration) (1, 2, 14)

Have students observe the production of heat and light energy from the combustion of magnesium ribbon using a bunsen burner.

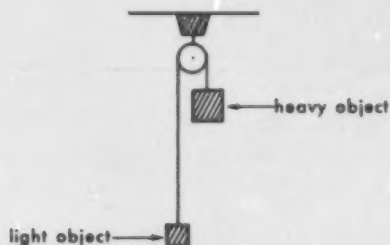
(Caution: Use safety glasses. Students should be instructed not to stare at the burning magnesium ribbon since a bright light is produced.)

The teacher should use a bunsen burner to ignite a small piece of magnesium. The combustion of magnesium demonstrates the conversion of chemical energy stored in magnesium to heat and light energy. During this combustion process, magnesium oxide is formed.

I-10. Gravitational Energy

(1, 2, 14)

Have students observe the ability of an object possessing gravitational potential energy to do work. Obtain a pulley, string (about 1.5 meters) and two objects of differing weights which can be fastened to the string. Anchor the pulley and set up the equipment as demonstrated in the diagram. Release the heavy object and observe what happens.



Students should observe that the heavy object, because it has a greater force of gravitational attraction for the floor, will fall. As a result, the lighter object will have work done on it by being moved upward.

I-11. The Conversion of Electrical Energy to Mechanical Energy

(1, 2, 14)

Have students observe the conversion of electrical energy to mechanical energy by plugging in an electric clock which has a second hand. Students should note the movement of the second hand.

I-12. The Conversion of Electrical Energy to Heat Energy and Mechanical Energy

(1 2, 14)

Have students observe the conversion of electrical energy to heat and then to mechanical energy by plugging in an electric coffee pot containing water. Electricity is converted to heat energy which then causes the movement of water into the coffee pot's glass bulb.

I-13. Energy Conversions

(13)

The first law of thermodynamics can be reinforced with concrete examples.

Have students construct a chart like the one below and fill in each box with an example of one form of energy being converted to another form. Example: Light is converted to heat in a solar collector, so write solar collector where light (top) intersects with heat (side).

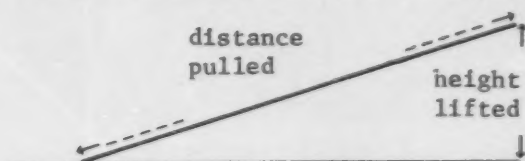
Converted To	Heat	Light	Mechanical	Chemical	Electrical	Nuclear
Heat						
Light						
Mechanical						
Chemical						
Electrical						
Nuclear						

Discuss student responses.

I-14. Simple Machines and the Second Law of Thermodynamics

(5, 14, 17)

Have students confirm the second law of thermodynamics by doing a simple experiment with the inclined plane. Obtain a plane and incline it. Obtain a force measuring device, string, and object to be dragged up the plane.



Determine and record the weight of the object. Measure and record the force exerted in dragging the object up the plane. Measure and record the distance that the object

is pulled along the plane and the height from the floor to which the object is finally lifted.

Calculate the work input and work output. Work input - exerted force $\times$ distance pulled, and work output - weight of object $\times$ height lifted. Students should discover that the work input is greater than the work output, thus realizing that using the inclined plane is not 100% efficient.

I-15. A Light Bulb and the Second Law of Thermodynamics (1, 2, 14)

Have students observe the results of the second law of thermodynamics by lighting a light bulb. Observe the results when a light bulb is turned on. Note that when a light bulb is plugged in, not all of the electrical energy is converted to light energy. Some of this electrical energy is lost in the form of heat energy as evidenced by the warmth of the bulb.

I-16. Energy, Technology, and the Story of Man (14)

Have students read the article "Energy, Technology, and the Story of Man," cited on page 13. As a result of their reading, students should have a general idea of the history of energy use.

I-17. The Life of a Colonial Farmer (17)

Have students read the excerpt below from "The Life of the Farmer"* and answer the questions following the reading. As a result of this reading, students should appreciate the difference between energy sources used by 18th century colonists and those used by people today.

5:00 a.m. Got up and fed the oxen, pigs, and chickens. Wife started fire and cooked breakfast. A cold morning. Frost everywhere. Milked the cow.

6:00 a.m. Ate pork and buttered cornbread for breakfast. Have to make another chair so our youngest child will have a place to sit. Maybe I can do it tomorrow.

7:00 a.m. Hitched up the oxen to the plow. Started to plow half our field. Will have to get ready to plant wheat and corn. Hope to finish plowing before next week.

11:00 a.m. Weather finally warmed up some. Wife and children spent the morning preparing the garden. Soon the time will come to plant onions, lettuce, and cabbage.

12:00 noon. Finally had lunch. Still thinking about making that needed chair. Had salted pork, and cornbread for lunch.

12:30 p.m. Went back to plowing. After cleaning up the lunch dishes, wife spun thread. We all need some new clothes for the summer. I'm thinking about trading a pig for new shoes for the family. Haven't got time to make shoes. Children finally got to go fishing.

3:30 p.m. Went to work on the fruit trees. Hope the blackbirds don't eat too much of the fruit this summer. Had to cut off all the dead limbs. Only worked on some of the trees. Too tired to trim them all. Had hoped to remove some tree stumps from the field. Maybe I can get to that before too long. Neighbor Thomas

*Reprinted with permission from: "The Life of the Farmer," The Americans, Edwin Fenton, editor. Holt, Rinehart and Winston, New York, 1975. pp. 45-56.

will help. Last week I helped him pull up stumps. Wife began to prepare supper. I'm glad children caught fish. We'll have them for supper with some boiled potatoes.

5:00 p.m. All of us had supper. Still thinking about making that chair. Wife and children got supper dishes cleaned up. Children brought in some firewood. I milked the cow and fed the live-stock again.

7:00 p.m. Started to get cold again. Said evening prayers and children went to bed. Wife mended. I cleaned my rifle. Reminded myself to get wood for the chair I must make.

8:00 p.m. Used the remaining light from the fire to write in my diary and read the bible.

9:15 p.m. So tired. Went to bed.

- What sources of energy were available to the settlers?
- The following tasks were done by the settlers. What source of energy was used for each of these tasks?

-Producing food _____
-Preparing food _____
-Building homes and barns _____
-Lighting and heating homes _____
-Preparing clothing _____
-Making furniture _____

- List two jobs performed by each member of the family.

-Mother _____
-Father _____
-Children _____

- In the colonial period, what do you think made one family wealthier or better off than another?

I-18. Animal vs. Inanimate Work Output

(12, 13, 14)

Have students study the table on p. 74. Students should then do the following:

- Graph the table of information for work animals and inanimate energy sources vs. time.
- Discuss the factors which may have influenced the trends indicated in the graph.

Animal Work Output vs. Inanimate Work Output*		
<u>Year</u>	<u>From Work Animals**</u>	<u>From All Inanimate Energy Sources**</u>
1850	5.4	3.6
1860	7.6	5.9
1870	8.4	8.5
1880	11.1	16.0
1890	14.4	30.3
1900	16.9	57.6
1910	19.0	142.8
1920	15.2	268.1

** (In terms of billion horsepower/hours)

I-19. Energy Resources Used in 1850 and 1900

(14, 17)

Discuss with students the reasons for the changes in total United States energy consumption by source from 1850 to 1900 as illustrated by the following table.

<u>Source</u>	<u>1850</u>	<u>1900</u>	<u>1950</u>	<u>2000</u>
Wood	90.7%	21.0%		
Coal	9.3	71.4		
Oil	—	2.4		
Natural Gas	—	2.6		
Hydropower	—	2.6		

Have students try to find data for 1950 and either locate through research or speculate on what the figures might be for the year 2000 and why.

I-20. Energy Consumption Through the Ages

(12, 14, 15)

Students should examine the table and then do the activities which follow.

<u>Society</u>	<u>Per Capita Per Day Energy Needs (Kcal) day</u>
Primitive	2,000
Early Civilizations (Agricultural)	12,000
Nineteenth Century (Industrial)	70,000
Twentieth Century	250,000

- Make a bar graph of society types vs. per capita energy consumption.
- Discuss possible factors leading to the changes in energy consumption.
- Explain whether you think the trend in per capita energy consumption will continue.

*From: Energy Conservation in the Home. United States Department of Energy, Washington, D.C., October, 1977.

I-21. Formation of Oil and Gas

(13, 14)

To help students better understand the steps involved in the formation of oil and gas from marine life, take the statements below and scramble them. Ask students to rearrange them in the correct sequence and explain their reasoning.

1. As marine creatures died, they settled to the sea bottom and were buried by layers of mud and sand.
2. The organic material in the mud and silt was changed to gas and oil. This change was probably a result of gradual decay, heat, pressure and, possibly, bacteria and radioactive actions.
3. Over millions of years, pressure compressed the deeply buried layers of mud, silt, and sand into layers of rock.
4. Earthquakes and other earth forces buckled the rock layers.
5. The petroleum migrated upward through porous rock until it became trapped under non-porous rock.

I-22. Fractional Distillation (Teacher Demonstration) (2, 14, 15, 17)

Fractional distillation of ethanol (or methanol) and of salt water can be demonstrated to show that a mixture of liquids may be separated by evaporation and the solids left behind.

Materials required are:

- hot plate
- distilling flask
- two corks to fit distilling flask with holes to fit thermometer and sidearm
- beaker into which flask will fit
- thermometer
- water-cooled condenser
- two 60 cm rubber hoses to fit condenser
- two 250 ml beakers
- graduated cylinder
- boiling chips
- 20 ml of ethanol (95%)
- 5 grams of salt (NaCl)
- three ring stands
- one ring
- two clamps

Demonstrate fractional distillation as follows:

Part 1 Salt and Water

1. Put on safety goggles.

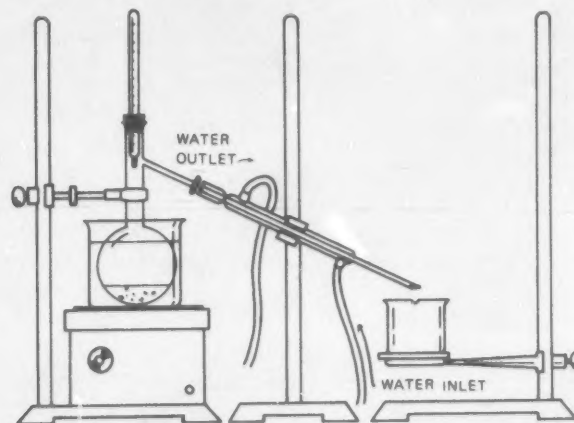
2. Dissolve 5g of NaCl in a small amount of water in 250 ml beaker.
3. Set beaker on hot plate and boil until almost all water has evaporated. Remove from heat and allow remaining water to evaporate. Turn off hot plate.
4. Ask students to describe what happened and to come up with a mechanism to collect the water if it was desirable to do so.

Part 2 Methanol and Water

1. Put on safety goggles.
2. Mix 20 ml of ethanol (or methanol) and 80 ml of water and boiling chips in distilling flask.
3. Set up distillation apparatus following the diagram provided.
4. Set flask in water bath on hot plate.
5. Observe temperature at which first distillate appears, and temperature at which distillation stops.
6. Turn off hot plate.
7. Note odor of distillate.

Discuss with students the similarities between this demonstration and the separation of crude oil, also a mixture of liquids. Some of the products of fractional distillation of crude oil are listed below with their distillation temperatures.

102°C — gases (liquified petroleum gases)
113°C — naptha (gasoline)
170°C — light gas oil (light furnace oil/kerosene)
266°C — gas oil (diesel oil/furnace oil)
371 C — heavy gas oil (waxes, asphalts, heavy fuel oils)



The process of obtaining useful petroleum products involves a series of steps. Have students read each of the descriptions* below, arrange them in the order in which they occur, and label each with the word which represents each step. (DRILLING, REFINING, LEASING, TRANSPORTATION, MARKETING, PRODUCTION, EXPLORATION) The transportation paragraph is used twice when describing this eight-step process of obtaining petroleum.

Only about one-third of the crude oil in a typical oil-bearing formation flows naturally so that it can be pumped out. The remainder is trapped in porous rock. Oil companies use a variety of secondary recovery techniques—water, chemical and gas injection, and combustion — within the formation to help the oil flow to the well-head. As oil becomes increasingly scarce, oil companies rely more and more on these expensive secondary recovery techniques. (4, Production)

Determining if a likely geological formation contains oil is the most costly industrial activity in America. On the average, only one "wildcat" well out of every six drilled produces oil or natural gas in commercial quantities. The cost of finding oil ranges from an average of \$200,000, for a well on land, to more than \$2 million, for offshore marine wells. (3, Drilling)

Petroleum geologists are trained to recognize structural features of surface formations that might indicate the presence of oil or gas. By measuring gravity and magnetism, and by use of seismic sound waves to measure underground echoes, geophysicists gather information about underground formations. Then the only way to find if petroleum is present is to drill a well. (2, Exploration)

The first step in processing crude oil is distribution. The crude oil is heated and piped under pressure to a huge— 15 to 20 story—fractionating tower. As the hot vapors rise, different hydrocarbons condense at different levels. Gases and gasoline condense near the top; farther down the tower, jet fuel and kerosene are removed; next diesel fuel and heating oils; and finally, near the bottom, lubricants, heavy oils, asphalts, and other residual products. The products require extensive additional processing and treatment. Today almost twice as much gasoline is obtained from each barrel of crude oil as in 1920. (6, Refining)

The land agent acquires property to drill on. Oil companies purchase the right to explore, drill for and produce any oil and natural gas found under the land. Usually the landowner may receive a bonus when arrangements are completed as well as an annual rental fee for each acre. In addition, landowners receive royalty payments for any oil and gas produced. (1, Leasing)

Many of the more than 2,000 products produced from petroleum—the synthetic fabrics and plastics sold in every department store—are made from less than five percent of the crude oil. But nearly half of every barrel of oil refined becomes gasoline.

*Reprinted with permission from Energy Adventure, AMOCO Educational Services, Chicago, Illinois 60680.

Some 200 plus U.S. refineries and approximately 12,000 distributors sell gasoline to service station dealers. Eight out of 10 service stations are owned or operated by local independent business people. (8, Marketing)

Almost 50% of all crude oil produced and refined in the U.S. is

moved efficiently through more than 227,000 miles of pipeline. Ships and barges transport another 45% via coastal and inland waterways.

Trucks carry 3%, mostly refined products, generally over relatively short distances. Less than 2% of the petroleum is transported by railroad tank cars.

(5, 7, Transportation)

I-24. The Energy Content of Oil

(4, 6, 13)

Oil possesses potential chemical energy which can be converted to heat energy. To determine the heat content of oil obtain the following materials.

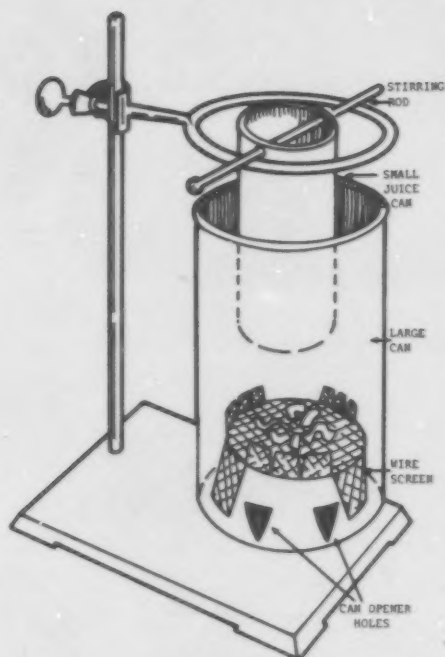
- | | |
|-------------------------------------|-------------------------|
| * fiberglass insulation | * can opener |
| * glass stirring rod | * lubricating oil |
| * Bunsen burner | * platform balance |
| * ring stand with clamp | * screen wire |
| * small juice can with metal bottom | * scissors |
| * thermometer (40°-150°C) | * matches |
| | * large metal juice can |

Note: Fiberglass insulation can easily be obtained from a lumber yard or hardware store. However, instead of using fiberglass insulation, you may want to use sand. Put sand in a baby food jar lid and then add lubricating oil.

(Caution: Safety glasses should be worn during the activity. Remind students that the oil will produce a black smoke at first. A hood should be used for this activity. Gloves should be used when handling fiberglass.)

Prepare the apparatus as follows:

1. Use a can opener to put holes in the sides of the larger can and then remove the top and bottom from the larger can.
2. Using scissors, punch a small hole in the side near the top of the small juice can for the stirring rod. Insert stirring rod.
3. Find the mass in grams of the 100 ml of water and put the water in the small juice can.
4. Read and record the temperature of the water in °C.
5. Make a small stand out of the piece of wire screen. (See the diagram.)



6. Cut a piece of fiberglass insulation about 2.5 to 3 cm in width and length. (Use gloves while handling the fiberglass.)
7. Place the small wire screen and fiberglass insulation on the platform balance and determine its mass.
8. Slowly drip 20-22 drops of lubricating oil into the fiberglass and determine the mass of the added oil. (NOTE: The mass should be about 0.3g.)
9. Set up the apparatus as shown in the diagram above.
10. Now remove the wire screen, fiberglass and oil from the balance.
11. Leaving the fiberglass on the wire screen, ignite the oil.
12. Raise the large can and cautiously push the burning oiled fiberglass under the juice can containing the water.
13. Lower the large can over the burning, oiled fiberglass.
14. After the oil has burned off the fiberglass, record the temperature of the water on the data sheet.
15. Cautiously raise the larger can and remove the wire screen containing the unburned fiberglass to see if you burned all the oil with which you started.

16. Determine the heat content of the oil by using the following equations:

Heat gained = temp. (x) mass of (x) .001 _____ Calories, or _____ joules
by water change/ water
water

Heat content = $\frac{\text{Heat output (heat gained by H}_2\text{O)}}{\text{Mass of oil}}$
of oil

Accepted value for heat content of oil is 10,800 Cal/kg or 45.19 mega-joules/kg

% difference = $\frac{\text{experimental result}}{\text{accepted value}} = \underline{\hspace{2cm}}$

I-25. Oil-Based Products

(1, 14, 15)

Have students examine the list of oil-based products in Appendix B-2. They can do the following based upon the list:

- Pick out all the items used by themselves and/or their families.
- Suggest which items they feel they could not do without.
- Suggest non-oil-based substitutes for items they deem necessities.
- Add to the list of oil-based products.

I-26. Natural Gas, A Clean Fuel

(6, 14, 15)

Have students note one of the advantages of using natural gas as a fuel for heating by doing the following experiment. Have students use tongs to hold the bottom of an evaporating dish over a candle. They should note their results. Then have the students use tongs to hold an evaporating dish over a bunsen burner.

Students should note that a black deposit coats the evaporating dish when held over the candle, but no observable deposit coats the evaporating dish when held over the bunsen burner flame.

Students should locate on a map the following areas which provide the natural gas consumed in New York State: Offshore Louisiana - 51%; Onshore Louisiana - 22%; Texas Gulf - 14%; Appalachian Illinois Basin - 7% (Other - 6%).

I-27. Formation of Coal

(13, 14)

The statements and illustrations* on the following page can be matched to provide students with an understanding of the coal formation process.

*From: The Energy Challenge, Federal Energy Administration (United States Department of Energy), Washington, D.C.

PLACE THE NUMBER OF THE
PICTURE IN FRONT OF THE
DESCRIPTION THAT FITS
IT BEST.

When the giant plants
died, they formed
rotted vegetable
matter called peat.
For thousands of
years, plants grew,
died, and formed
layer upon layer of
peat.

(2)

When the seas were
gone again, heat and
pressure from the
layers of rock
changed the peat
into coal.

(4)

More than 250 million
years ago, forests of
gigantic ferns, trees,
and grasses covered
vast swamp lands and
stored up energy from
the sun.

(1)

Later, when the sur-
face of the earth
changed, seas covered
the land and deposited
layers of shale, lime-
stone, and other rock
on the peat.

(3)

Compare and contrast coal formation with oil and gas formation (I-21.)

I-28. Heat Content of Major Coal Types

(14, 15)

There are different types of coal which vary in their heat content. By examining the graph in Appendix B-3, students should be able to compare the heat content of the various types of coal and be able to answer the following questions.

- What does this graph show?
- Finish this sentence: *The greater the number of BTU's, the _____*
- Looking only at this graph, why might utility operators wish

HOW COAL WAS FORMED



PLACE THE NUMBER OF EACH PICTURE IN
FRONT OF THE DESCRIPTION THAT FITS IT
BEST.

to buy anthracite or bituminous coal instead of subbituminous or lignite?

- Subbituminous coal is much in demand today. What could be one reason? Can you think of others?

I-29. Surface Mining vs. Underground Mining

(14)

Coal may be obtained by strip mining or underground mining. In strip mining, huge bulldozers and power shovels are used to remove coal from a shallow seam near the Earth's surface. In underground mining, a tunnel or shaft is built within the Earth to the seam of coal, sometimes many hundreds of feet below the surface. Workers and equipment remove the coal through the tunnel or shaft. Give students the worksheet below.

Read each set of statements below.* If there were nothing else to consider, would you think that strip or underground mining (or both) is the best way to obtain coal? Write your choices on the blanks at the left using (S) (for strip) or (U) (for underground).

Strip Mining

Underground Mining

- | | |
|---|--|
| (S) 1. Each miner can produce 30 tons of coal a day. | Each miner can produce 10 tons of coal a day. |
| (S) 2. 90% of the coal in a surface mine can be removed. | 50-60% of the coal in a deep mine can be removed. |
| (S) 3. In 1974, surface-mined coal cost \$11.11 a ton. | In 1974, deep-mined coal cost \$19.86 a ton. |
| (U) 4. Forest and fields, along with their topsoil, are turned over before the coal is removed— at a rate of 1000 acres a week. New laws in every state require land reclamation, but the cost is added to the price of coal. | Much less damage to land and environment. |
| (Both) 5. Some coal, very close to the Earth's surface can only be recovered by surface mining. | Some coal, very deeply buried, can only be recovered by deep mining. |

It would be easy to decide how to mine coal if there was only one set of facts to consider. As you have seen, however, there are many. What would you say is the main advantage of surface mining? (economic)

What would you say is the main advantage of deep mining? (environmental)

Can you think of a compromise?

*Adapted from: The Energy Challenge, Federal Energy Administration (United States Department of Energy), Washington, D.C.

I-30. Uses of Coal

(13, 17)

There are three major uses of coal in the United States: to generate electricity, to make steel, and to provide energy in industry. Explain to students that coal is used to generate one-half of the electricity in the United States, that it is used to produce coke, a necessary ingredient in the steel making process, and that it provides heat for the manufacturing process.

Have students give examples of:

- the uses of coal-generated electricity (washer, power tools, clock, etc.)
- products made from coal-smelted steel (autos, tools, cans, etc.)
- products of the paper and cement industries

Discuss the implications of the widespread use of coal and whether or not other energy resources can or should be substituted for it.

I-31. Energy from Falling Water

(1, 6, 17)

A hydroelectric power plant uses falling water to spin turbines for generating electricity. Have students demonstrate the ability of falling water to do work.

Obtain some cardboard, a toothpick, thread, and paper clips.



#1



#2



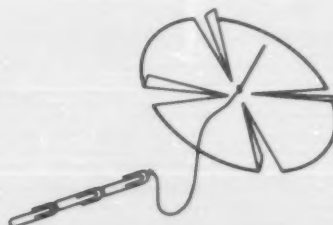
#3



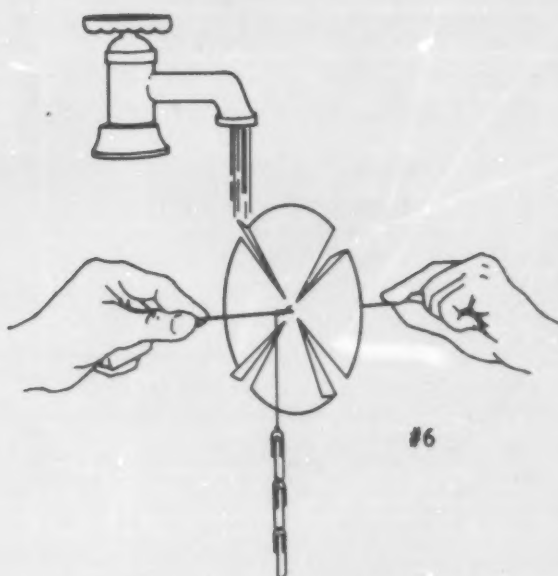
#4

Cut four slits in a cardboard circle (#1) and fold back the edges as shown (#2). Push the toothpick through the center of the circle (#3). The toothpick is the water wheel shaft and the folded parts of the cardboard are the blades.

Fasten one end of a piece of thread about 17 cm long to a chain of three paper clips (#4). The other end of the string should be fastened to the toothpick (water wheel shaft) (#5). Be sure to tie the thread tightly enough to prevent slipping.



#5



Place the edge of the wheel under a stream of water (#6). Hold the ends of the toothpick lightly between your fingers. The water wheel should turn and wind up the string of paper clips on the shaft.

Students should compare this activity to the function of a hydroelectric plant, (See I-32, I-33 below.)

I-32. Location of Hydroelectric Facilities

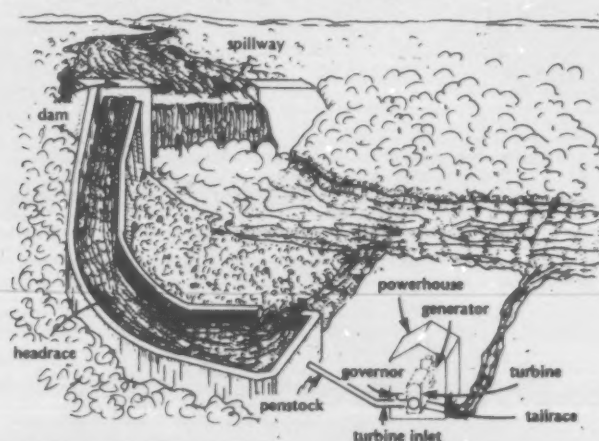
(9, 14, 16)

Have students formulate a hypothesis concerning areas of hydroelectric facility concentration in the United States. They should consult a relief or topographic map for guidance. In the hypothesis, students could include criteria for siting of such a facility. After the hypothesis is completed, students may examine the map, "Installed Hydroelectric Capacity" (Appendix B-4) and locate major installations. They may then be asked to evaluate their hypothesis based on the map and discuss implications for future hydroelectric facility development.

I-33. A Hydropower Installation*

(2, 14)

Have students explain the general construction of a dam which is used in a hydroelectric facility by studying the diagram.



A hydropower installation

*Reprinted from: Renewable Energy: A Background Text, Solar Energy Project, SUNY at Albany, 1400 Washington Ave., Box 22 425, Albany, N.Y. 12222

I-34. Nuclear Fission Model (20, 22, 23)

After discussing the fission reaction as shown,* students can create a model of such a reaction using dominoes.

The continued fissioning of U-235 that occurs in a nuclear reactor is called a chain reaction. Set up dominoes in two different patterns** as illustrated and have students predict what will happen in each case.

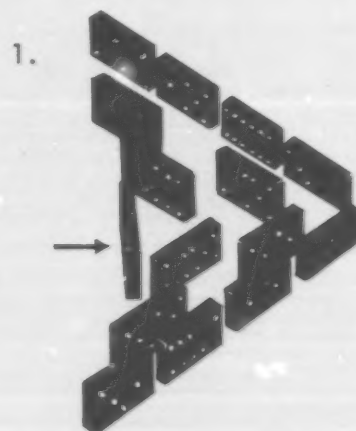
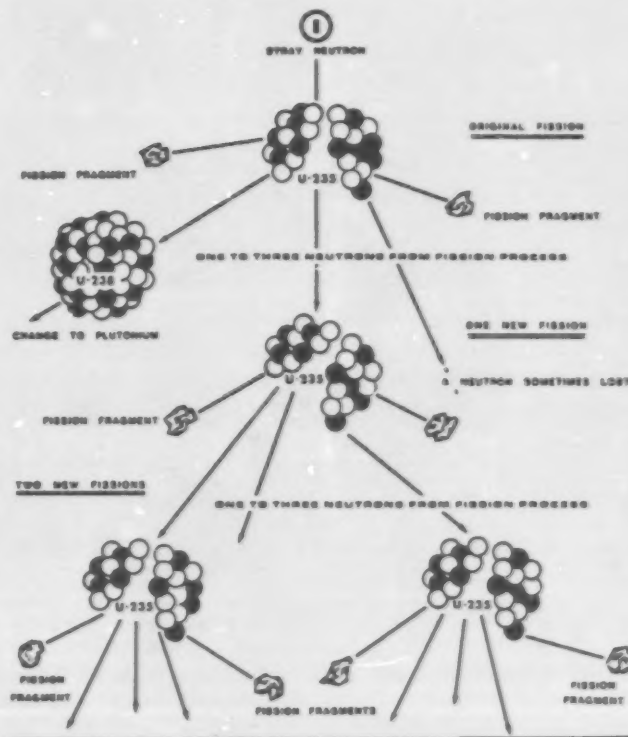
- Push over the dominoes indicated by the arrows.
- Describe what happens.
- Compare each domino sequence with what actually happens in a nuclear reactor.
- Ask students to develop additional domino models.

The original fission, represented by the first domino, releases two new neutrons and tips over two more dominoes. The process continues until complete. The second reaction illustrated shows a slower fissioning process in which some of the neutrons are wasted (absorbed by control rods) and thus, some dominoes do not fall.



2.

NUCLEAR FISSION CHAIN REACTION



1.

*Reprinted with permission from: Energy, Pennsylvania's Energy Curriculum for the Middle Grades, Pennsylvania Department of Education, Harrisburg, PA 17126, p. 50.

**Reprinted with permission from: Nuclear Experiments you can DO...from Edison, Thomas Alva Edison Foundation Inc., Southfield, Michigan 48075, 1976, pp. 9-11.

I-35. Nuclear Waste Treatment

(8, 14, 16)

Using nuclear fission as an energy source for the production of electricity creates the problem of storing the radioactive waste. Students should examine appropriate journals and magazines to determine what current storage techniques are:

- What are the advantages and disadvantages of these current techniques?
- Would you be willing to have a storage facility in your area? Is it possible? Probable?

I-36. Log of Electricity Use

(1, 2, 14)

Students may be unaware of the variety of ways in which they use electricity daily. Direct them to construct log sheets on which they record as many uses of electricity as possible.

Date	Activity	Source/Appliance Used
3/20/8__	wake up	clock radio
3/20/8__	shower	electric hot water heater
3/20/8__	breakfast, etc.	toaster; coffee maker or hot water (electric stove)

Encourage students to consider all lighting, heating, food preparation and all battery-operated items used. The detail recorded by individual students in carrying out this assignment will vary tremendously. Discuss the completed logs in class. Extend discussion to include the possible alternatives to the reliance on electricity which has been demonstrated.

I-37. Electricity Production

(17, 19)

Have students study the diagram, "Electricity-Production," found in Appendix B-5. Based on their analysis of the three types of power plants, students should be able to develop a general model of an electric power plant and show how each type of power plant follows this general model. They should then explain the differences among these power plants.

Students should realize that a power plant consists of an energy source, an energy converter (the turbine-generator system), and a transmission system.

(Note: The transmission system is not apparent in the case of the nuclear and hydroelectric power plants.)

I-38. Turning a Turbine

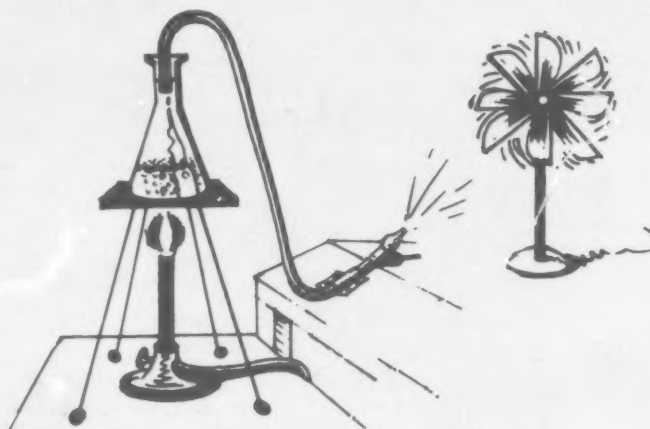
(20, 22, 23)

Through a simple activity students can model the use of steam from burning fuels to turn turbines of a generator. Materials needed are:

- 250 ml pyrex flask
- one hole stopper
- short glass tubing to fit stopper
- $\frac{1}{2}$ in rubber tubing to fit glass tubing
- glass portion of a medicine dropper
- hot plate or bunsen burner
- ring stand, ring, and wire gauze
- boiling chips
- safety goggles
- pin wheel
- paper towel

(Caution: Students should wear goggles. They should use boiling chips, and take care not to produce steam at a faster rate than it can escape from the tubing.)

1. Put 100 ml of tap water and boiling chips into a 250 ml pyrex flask. Fit the glass tubing into the stopper and attach the rubber tubing to the glass tubing. Stopper the flask. Insert the glass portion of a medicine dropper into the free end of the rubber tubing, exposing the tapered end. Set on hot plate or bunsen burner stand. (See illustration.)



2. Wrap paper towel around tubing where it will be held. When steam begins to issue from the medicine dropper, grasp the towel-wrapped tubing and position dropper in such a way as to spin the spinwheel. Students should be able to discuss the energy conversions-chemical, heat, mechanical-in the experimental model and relate them to portions of an electrical generating system. Discuss ways of improving the system or making it more efficient.*

I-39. Producing an Electric Current

(9, 16, 17)

In power plants, electricity is produced when a moving turbine rotates an electromagnet between stationary coils. To demonstrate this phenomenon, obtain a U magnet, galvanometer, copper wire, and cardboard tube. Set up the apparatus as shown on page 88.

*Reprinted with permission from: "Energy: Pennsylvania's Energy Curriculum for the Middle Grades," Pennsylvania Department of Education, Harrisburg, PA 17126, pp. 38-39.

1. Connect the ends of the copper wire to a galvanometer and, while holding the wire vertically, move the wire vigorously between the poles of the U magnet, cutting across the magnetic field.

- What happened to the needle on the galvanometer?

2. Make a coil of wire by wrapping the wire (25-40 turns) around a cardboard tube. (See Figure 2.) Move the coil between the poles as shown on Figure 2.

- What happened to the needle of the galvanometer?
- Did the amount of wire affect the movement of the pointer? How?

Figure 1

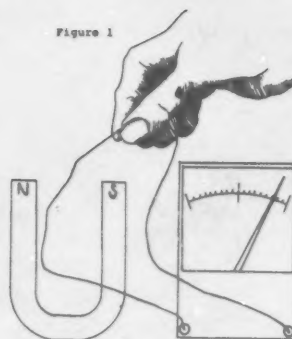
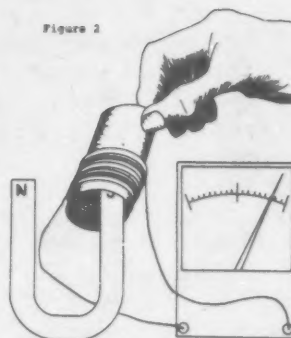


Figure 2



Students should have discovered that electricity can be produced by the motion of a wire through a magnetic field and that the amount of electricity can be increased by increasing the amount of wire being used. They may also be able to relate the concept of alternating current to the up and down motion of the wire.

I-40. Efficiency Comparison of Hot Water Heaters

(8, 14)

Some uses of electricity are not as efficient when compared with an alternate fuel use. Have students solve this efficiency comparison problem:

- Which is more efficient, an electric hot water heater with an efficiency rating of 79% or a gas hot water heater rated at 46%?

Consider the efficiency of producing electricity in this comparison. In the production of electricity from a fossil fuel plant, the boiler is 88% efficient, the turbine 47% efficient, the generator 99% efficient, and the transmission system 80% efficient. (Remember when energy is converted from one form to another, some is always lost to the surroundings as heat.)

Answer: The gas water heater is 46% efficient, while the electric is $.88 \times .47 \times .99 \times .80 \times .79 \approx 26\%$ efficient.

I-41. The Main Parts of an Electric Power Plant

(1, 17, 20)

To understand the basic parts of an electric power plant, obtain a light bulb and socket, two test leads, string, small motor, and a weight, (about 4 newtons).

1. Fasten the motor to something stationary.
2. Connect one end of a string (1 meter) to a motor shaft and the other end of the string to the weights.
3. Connect the test leads to the light bulb and motor.
4. Lift the weight by winding the string around the motor shaft.
5. Release the weight and observe what happens.

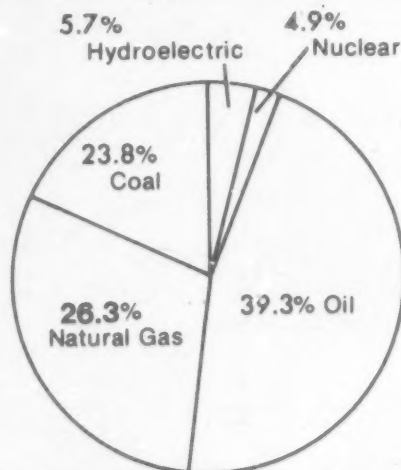
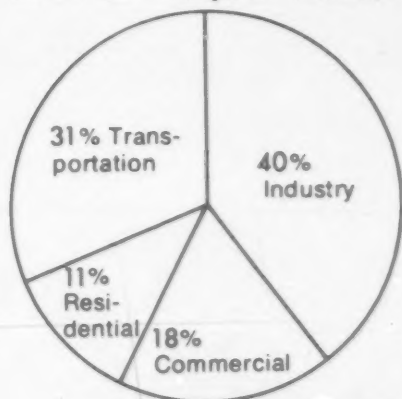
Students should see the light bulb light. They might predict that the heavier the weight, the brighter the bulb. Students should be able to compare the parts of a power plant to the parts of the equipment in this experiment.

Parts	Power Plant	Experiment
Energy Source	Fossil Fuel Hydroelectric Nuclear	Falling weight
Energy Conversion	Turbine-generator system	Motor (acting like a generator)
Energy Transmission	Transmission system	Test leads

I-42. Energy: Sources and Uses

(13)

Have students do research on the sources of energy and how it is used in the United States. They should present the information in chart or graph form, possibly as in the examples* shown.



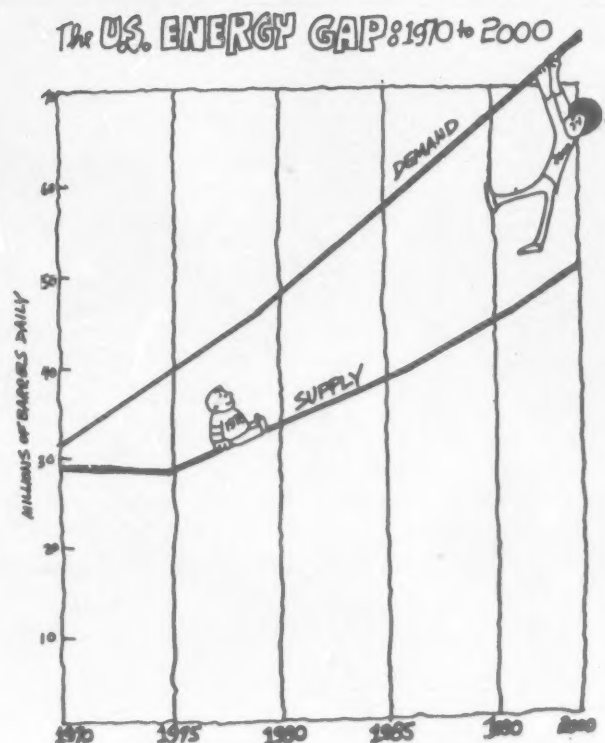
- * Discuss the comparative ease or difficulty involved in the location, production, transportation, storage, waste treatment, etc. of each of these energy sources.

*Graphs from The Energy Challenge, Federal Energy Administration (Department of Energy), Washington, D.C.

I-43. The Energy Gap (14, 15)

Ask students to study the graph* and answer the accompanying questions.

- According to the graph, what happened to the demand for energy between 1970 and 1975?
- According to the graph, what will happen to energy consumption by 2000?
- What will happen to energy supply?
- In 2000, there will be a gap. Using the words demand and supply, write a statement that describes this gap.
- Why is 2000 trying to pull down the demand curve?
- What are the limitations of a graph produced for publication in 1980?



I-44. Supply and Demand: Shortage and Surplus

(8, 14)

While energy demand has continued to rise, the supply of energy has not. Have students investigate the complicated relationships of supply and demand by considering the scenario described below**. They should select appropriate answers from those provided, some of which may be used more than once.

Possible Answers

1. 40
2. lowered
3. supply
4. 200 gallons
5. \$13.00
6. 5 gallons
7. shortage
8. raised
9. surplus
10. 160 gallons
11. demand
12. \$260.00

Mr. Smith, a gasoline station owner, received 200 gallons of gasoline regularly each week. His 20 regular customers were used to buying all the gas they needed. Although some weeks some people bought more and some bought less, average use was 10 gallons a week. The total demand for gasoline each week, then, was (200 gallons). As you can see, Mr. Smith's supply was (200 gallons). Everybody was pretty happy about the whole thing. The supply was equal to the (demand).

Mr. Smith charged \$1.30 a gallon for gasoline, a price that was about the same as that charged by the other station in town. Each regular customer spent an average of (\$13.00) each week. Mr. Smith received (\$260.00) for gasoline. When the other station reduced its

*Reprinted from: The Energy Future Today, Grades 7, 8, 9, Social Studies by the National Science Teachers Association for U.S. Department of Energy, Office of Consumer Affairs, April, 1980.

**Adapted from: Energy Challenge, Federal Energy Administration (Department of Energy), Washington, D.C.

price per gallon by a dime, four of Mr. Smith's regular customers deserted him and went across the street. He was still getting a delivery of 200 gallons a week but now the demand was only (160 gallons). He had (40) gallons left over. This unbought quantity of gasoline is called a (surplus). To get rid of the surplus, Mr. Smith (lowered) his price. His remaining regular customers bought up the (40) gallons at the new price.

Several weeks later, Mr. Smith and the other station received only 100 gallons of gasoline. Their suppliers were short of gasoline that week. Their customers' demands were still the same, so the pumps soon became empty. "No More Gas!" the sign in front said. Halfway through the week, Mr. Smith had a (shortage) of gasoline. By still charging \$1.30 a gallon, he didn't make enough to pay the costs of his station.

The next week he raised the price to \$2.60 a gallon. Even at the higher price, most of his customers still had to buy gas to drive to work and do errands, so he sold all 100 gallons. How much money did he receive? (\$260.00). What was the average amount each of the 20 regular customers spent? (\$13.00). What was the average amount of gas each customer used? (5 gallons).

Some of Mr. Smith's customers were on a fixed budget and couldn't afford to spend more than \$13 a week for gas. Some customers got to the station after the pumps were empty and couldn't get all they needed. Some of the other station's customers came over to Mr. Smith's station. The demand was greater than the (supply). Mr. Smith raised his gasoline prices again.

Discuss in your class ways in which the dealers and the customers solve their supply problems.

I-45. Demand and Advertising

(9, 10, 16)

Have students investigate the impact of advertising on demand for products. Suggest they study radio and television advertising, keeping a log of the commercials they hear and see, noting product, approach, intended audience, time of day, program carrying the advertising, etc. Once data have been collected for a few days, discuss the following:

- What are the relationships between time of day/type of program/product? (e.g., Sat. a.m./cartoons/ children's cereal, etc.)
- Can you separate fact from suggestion/hyperbole in these commercials?
- Did any commercials influence you to purchase the product being sold? Why did this happen?
- Do you think advertising increases demand... that advertisers get their money's worth?
- How is this type of induced demand related to need for the product?

I-46. Automobile Use in the Family

(9, 10, 16)

Reduction in automobile use would save energy. Have students formulate a hypothesis as to whether their own families could reduce automobile use with a minimum of inconvenience. They will need to devise a method for checking the accuracy of their hypothesis. One approach would be to note the dates, times, destinations, and distances traveled by automobile for a week. Based on this information, students could then determine whether or not family members could agree amicably to curtail automobile use if reasonable alternatives were suggested.

I-47. Efficiency

(5, 12, 14)

Simple machines can be used to demonstrate the concept of efficiency. Have small groups of students determine the efficiency of inclined planes with different surfaces (rough to smooth) and pulley systems. Ask the students to answer the following questions relating to each of these simple machines.

- Compute the input and output of each machine. What is the loss of energy in each case?
- How is the efficiency of a machine determined?
- List several ways in which efficiency can be increased. What factors decrease efficiency?
- What was the maximum efficiency (percentage) obtained for each simple machine?

Expand the discussion to include more complex machines.

- Give as many reasons as you can to explain why some automobiles run 30 miles on a gallon of gasoline while others run only 12 miles on a gallon. Why is it important to get maximum mileage?
- Explain why better-paved roads might improve the gas consumption of automobiles. Is this increase significant in terms of conserving fuel? Explain.*

I-48. Gasoline Conservation

(13)

Students should solve the problems below and discuss the gasoline conservation potential implicit in each.

1. Mr. Lucas filled his car's gas tank and noted an odometer reading of 36,271. The next time he refueled, it took 12 gallons to fill the tank and the odometer read 36,551.
 - How many miles per gallon did the car average between fillups? (23.3).

*Reprinted from: Living Within Our Means: Energy and Scarcity, 7-12, New York State Education Department, Albany, NY 1974. p. 47.

2. A woman travels from Albany to Boston and back, a distance of 320 miles, and her car averages 37 miles to the gallon.
 - How many gallons are required to make the trip? (8.6)
 - How many gallons would be required at 16 miles per gallon? (20)
 - What would the cost be for each trip if gasoline were \$131.9 cents per gallon? (\$11.34) & (\$26.38)
3. How far can a car go on a tankful of gasoline if it averages 22 miles per gallon and holds 12 gallons? (264 miles)
 - How much farther could it travel if, instead, it averaged 35 miles per gallon? (156 miles)
4. Correct tire inflation (See I-51.) can save the average driver up to 50 gallons of gasoline per year.
 - If gasoline costs \$131.9 cents per gallon, how much money would this save in a year? (\$65.95)
5. Regular tune-ups can save the average driver 175 gallons of gasoline a year.
 - How much savings is this if gasoline costs \$131.9 per gallon? (\$230.83)
6. Driving at 70 mph can consume approximately 25% more gasoline per mile than driving at 50 mph. Assume that on a 500-mile trip, while traveling at 50 mph, your car has consumed 20 gallons of gasoline.
 - How much more would it consume if you had traveled at 70 mph? (5 gallons)
 - How much more would this cost if gasoline costs \$131.9 per gallon? (\$6.60)

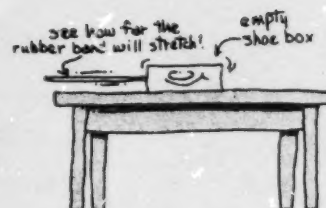
As a summary of the activity, have the students describe what they feel would be their own automobile selection, use, and maintenance behavior. Presumably, their descriptions would reflect gasoline conservation considerations.

I-49. Effect of Mass on Force Required to Move an Object* (5, 14, 17)

This simple activity demonstrates that the more mass an object has, the greater the force required to move it. Materials needed are shoe boxes, pencils, heavy weights (or books), and an assortment of rubber bands.

*Adapted from: Conservation: Science Activities in Energy, The American Museum of Atomic Energy, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37830. No. 13.

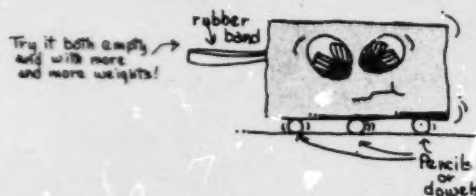
1. Attach a rubber band securely to the shoe box so that the box can be pulled along the table top. Measure how long the rubber band will stretch with the box empty.



2. Now fill the box with books or weights and repeat the experiment. Add more weights and repeat.



3. Put some pencils or dowels under the box and try pulling it.
4. What are the implications of this experiment for automobile design and gasoline conservation?



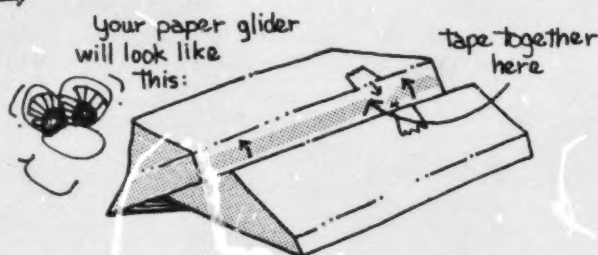
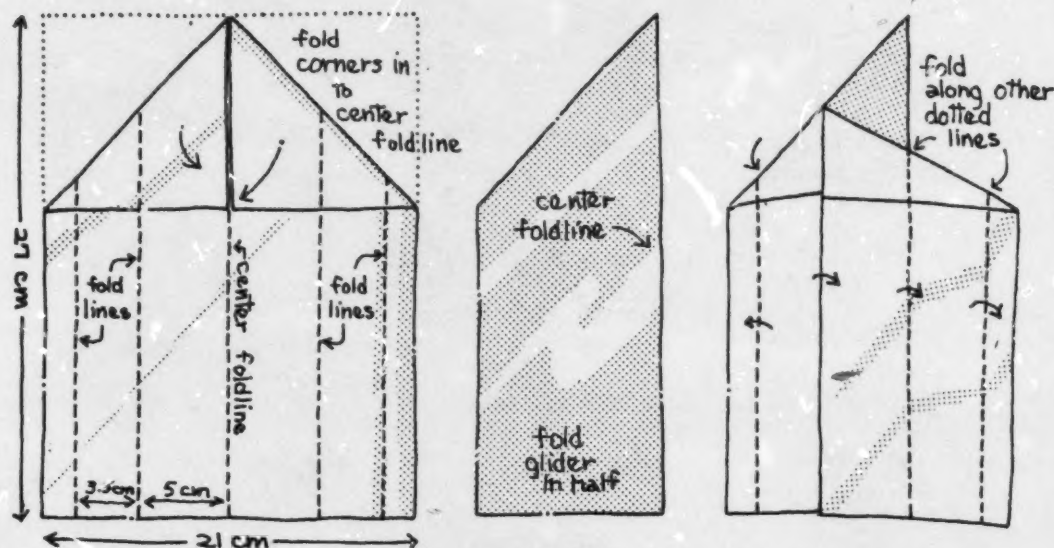
I-50. Efficient Construction of Paper Gliders*

(11, 13, 19, 23)

Airplane design can contribute to fuel efficiency. In this activity, have students construct a variety of paper gliders in order to determine those factors which lead to greater aerodynamic efficiency. The materials required include 21cm x 27cm sheets of paper (one sheet for each model), scissors, paper clips, two-sided adhesive tape, and a meter stick.

*Adapted from: Wind Energy: Science Activities in Energy, The American Museum of Atomic Energy, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37830, No. 1.

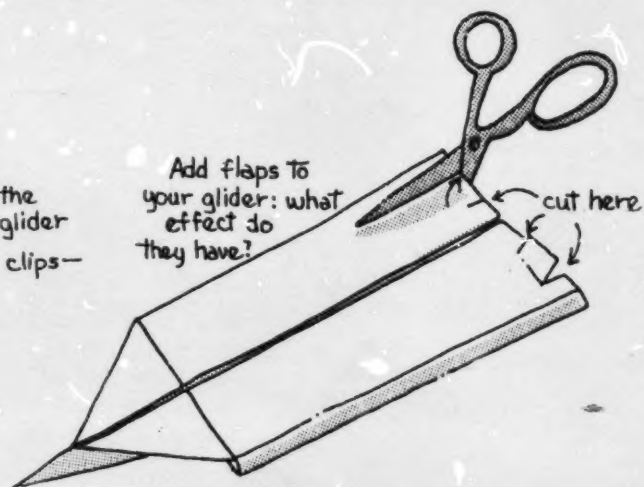
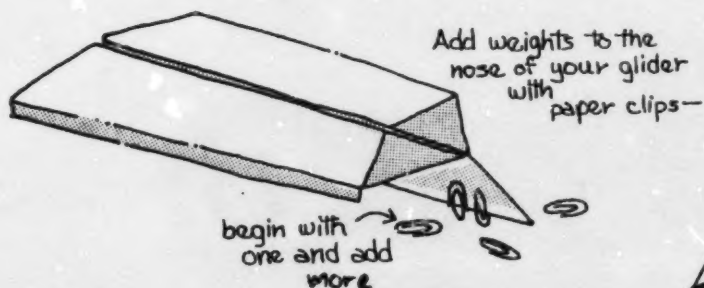
1. Have students construct a standard paper glider following the diagram below.



2. Students should then determine the average distance that the glider will travel in several trials.
3. Students should be given a set of variables to try in order to study factors involved in increasing the distance traveled. Examples might be:

- Adding weights

- Adding flaps



- Using different combinations of weights and flaps

- Using different wingspans or types of paper

From the result of their investigation, students should present the most aerodynamically efficient model. Have them compare various models and then design an experiment to determine the most efficient model in the class. Such variables as launching speed and height from which the glider is launched should be controlled. Once the most efficient model is designed, students should try to determine what particular factors led to the design modification(s) that produced it.

I-51. Tire Inflation and Gasoline Conservation* (5, 14, 17)

Two students with bicycles can demonstrate the effect of tire inflation in the following manner:

1. Inflate the tires on one bicycle to the recommended pressure.
2. Inflate the tires of the other bicycle to half the recommended pressure.
3. Have two students of similar weight ride side by side, pedaling at the same speed. When they reach a certain point, they should coast the rest of the way.
4. Measure and compare how far each one goes.

What are the implications for automobile gasoline conservation?
(See I-48)

(Note: This is an excellent activity for discussion of controlled experimentation and reduction of variables)

I-52. Energy Savings in Recycling** (13, 14)

Instruct students to use the information in the table provided to construct a bar graph comparing energy savings in the use of various recycled materials. They can then:

- Discuss the value of recycling from a conservation standpoint.
- Offer explanations for much higher savings in one material over another.
- Find the energy input required to make some of these materials from raw materials.

*Adapted from: Conservation: Science Activities in Energy, The American Museum of Atomic Energy, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37830. No. 14.

**Adapted from: J. Fowler, Energy Factsheet #10 (revised, unpublished).

The table shows the percent of energy saved in recycling various metals and other products as opposed to producing them from virgin resources. As used here, recycling is defined as including the collection, transportation, and the processing of these materials.

<u>Material</u>	<u>Energy Saved</u>
Steel - 40% scrap	10%
- 100 % scrap	47%
Aluminum	96%
Ingot	97%
Copper	89-95%
Glass Container	8%
Polyethylene Plastics	97%
Newsprint	23%

I-53. Preventing Unwanted Heat Loss or Gain

(1, 11, 14)

Insulation and appropriate building materials are important in preventing unwanted heat loss or heat gain. In the activity, students will construct a container that can prevent an ice cube from melting for three hours. Materials include uniformly-sized ice cubes, an assortment of materials to make ice cube boxes, and various types of insulating materials. Have students design and build their containers using the materials provided and test them. At the end of three hours, examine the ice cubes to see which containers preserved them best.

You may wish to ask students to design an experiment to determine which ice cube box keeps the ice cube the longest.

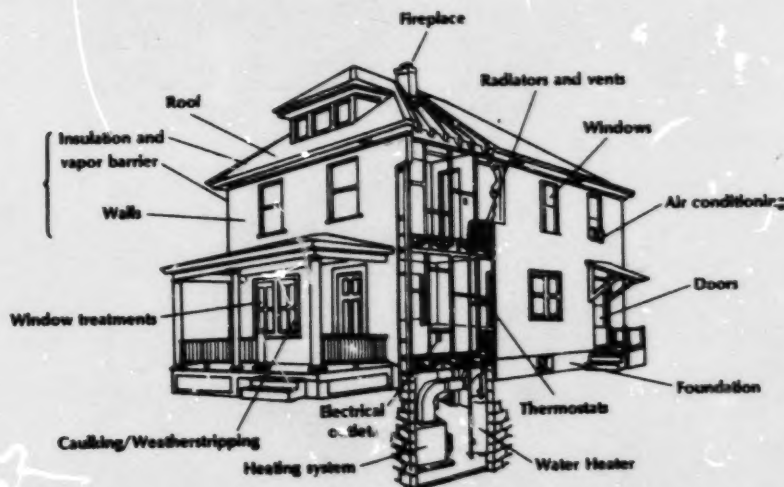
Conclude by discussing what the students have learned about insulation in the context of home heating and cooling.

I-54. Targets for Energy Conservation

(1, 8, 15)

A reduction in energy consumption can be achieved in most houses. Have students study the illustration below. As a pretest, ask them to name one way to conserve energy at each of the thirteen labeled areas of the house shown.

Targets for Energy Conservation



Following the pretest, discuss with the class the means for conserving energy at each of these thirteen locations around the house as described below.*

TARGETS FOR ENERGY CONSERVATION

- Caulking/Weatherstripping
 - 1) Use caulking for cracks and air leaks where there are no moving parts.
 - 2) Use weatherstripping on doors and windows where there are movable parts.
- Windows
 - 1) Install storm windows or plastic coverings.
 - 2) Seal air leaks with weatherstripping and caulking.
 - 3) Close curtains or drapes at night and lower shades.
 - 4) Replace cracked or broken panes.
- Walls
 - 1) Install proper insulation with a vapor barrier on the "warm side".
 - 2) Caulk seams, moldings, etc. for air leaks.
- Roof
 - 1) Install insulation in the eaves of a heated attic or in the floor of an unheated attic.
 - 2) Be sure that the vapor barrier is on the "warm side".
 - 3) Check for proper ventilation.
- Fireplace
 - 1) Close fireplace damper when fireplace is not in use.
 - 2) Have chimney cleaned at least once a year.
 - 3) Use a fireplace insert or glass doors to save more heat.
- Radiators and vents
 - 1) "Bleed" trapped air in radiators.
 - 2) Close hot air vents in rooms not in use.
 - 3) Be sure that radiators and vents aren't blocked or covered.
- Air Conditioning
 - 1) Set central air conditioning at 78°F or higher.
 - 2) Clean or replace air filter.
- Doors
 - 1) Install storm door.
 - 2) Weatherstrip and caulk doors.
 - 3) Have insulated doors to the attic and outside.
- Foundation
 - 1) Install proper insulation and vapor barrier, especially in crawl spaces.
 - 2) Caulk sill plate (where house frame attaches to foundation).
- Thermostats
 - 1) Set at 65°-68°F during the day and 55°F at night.
 - 2) Use clock thermostats if possible.
- Water Heater
 - 1) Set thermostat at 120°F or lower.
 - 2) Insulate hot water tank and pipes.
 - 3) Install flow restrictors on hot water taps.
- Heating System
 - 1) Adjust oil and gas burners.
 - 2) Replace air filters.
 - 3) Insulate hot air ducts.
 - 4) Use a humidifier to increase comfort at lower thermostat settings.
- Electrical Outlets
 - 1) Caulk around outlets to prevent air infiltration.
 - 2) Unplug small appliances for safety when not in use.

Retest the students after this discussion and compare the results with those of the pretest.

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I-55 Clean and Cheap

(5, 12, 14)

Students can do the following activity at home to determine the amount of energy used when taking a bath or shower. (For the purpose of the activity, it is assumed that all the water collected in the shower was heated to 140°F.)

1. Measure the length and width of the tub or shower stall *IN FEET*. Record below. The next time you bathe, close the drain and measure the depth of water that accumulates. Record below *IN FEET*.

length = _____ ft., width = _____ ft. depth = _____ ft.

2. Multiply these three measurements (Be sure you use feet, or fractions of feet) to obtain the total VOLUME of water used ($l \times w \times d = \text{volume}$).

Volume = _____ cubic feet

3. One cubic foot of water equals approximately 8 gallons of water. Convert cubic feet to gallons below.

_____ cu. ft. $\times$ 8 gal/cu. ft. = _____ gallons of water

4. The amount of energy required to heat the water differs, depending on the type of water heater.

- Electric water heater set at 140°F = 2700 BTUs/gal.

- Gas or oil water heater set at 140°F = 1200 BTUs/gal.

Calculate the number of BTUs required to heat the water for your bath/shower.

_____ gals. of hot water $\times$ _____ BTUs/gal. =
(2700 or 1200 - depending on your water heater)
_____ BTUs

5. List as many methods as you can for decreasing the energy you use when bathing.

• Explain why it is that, although your water heater temperature setting is 140°F when installed, it probably should be lower.

I-56. Appliances and Energy Use

(14)

Various appliances use different amounts of energy. To determine which appliance would save the most energy if its use were reduced, have students do the following activity.

1. Using the numbers 1-12, rank the appliances listed on the following page according to the amount of energy you think each consumes in a year. (1 = the least energy consumed; 12 = the most energy consumed.)

2. Ask to see Appendix B-7 and use the right hand column (kwh) to determine the actual ranking. Use annual kilowatt hour consumption.

<u>Appliance</u>	(1) Your Ranking	(2) Actual Ranking
Hair dryer (hand-held)	_____	_____
Carving Knife	_____	_____
Air Conditioner (room)	_____	_____
Refrigerator/freezer	_____	_____
Automatic coffeemaker	_____	_____
Color TV	_____	_____
Dishwasher	_____	_____
Clothes dryer	_____	_____
Washing machine	_____	_____
Toaster	_____	_____
Microwave oven	_____	_____
Hot water heater (quick recovery)	_____	_____

- List as many methods as you can for decreasing the energy consumption of these appliances.
- Which jobs performed by these appliances can you readily perform in a way that would reduce energy consumption?

I-57. Using an Energy Efficiency Rating Label (14)

Have students look at the "Energy guide" label on the next page and point out the main features. Discuss with them the usefulness of this label, using these questions.

- If electricity costs 10¢/kwh in your area and you buy this model how much will it cost to operate per year? (\$182)
- If electricity costs 10¢/kwh in your area and you buy the model with the highest energy cost, how much more will you pay to use it than this model in one year?
(2 x \$132 = \$264 - \$182 = \$82)
- You are looking at two refrigerators. Refrigerator A has an energy cost, in your area, of \$182 per year, and refrigerator B costs \$136 to operate per year. Refrigerator A is on sale for \$138

less than refrigerator B.
How long will it take to
pay off this difference
through energy savings if
you buy refrigerator B?
(3 years)

Questions such as these can be
used to illustrate that choosing
an efficient appliance saves
both energy and money.

I-58. Fluorescent vs. Incandescent
Lighting (14)

Have students determine what is
more energy efficient, fluorescent
or incandescent lighting by doing
the following activity. Materials
include several fluorescent and
incandescent bulb packages. To
determine the efficiency,
students will divide the number
of lumens by the wattage for the
various bulbs. (This information
should be provided on bulb
packages.)

Wattage is the rate at which
the light bulb uses energy
(input) and lumens is the
rate at which the light bulb
gives off energy (output).
The efficiency will be in
units of lumens per watt.

$$\text{Efficiency} = \frac{\text{Output (lumens)}}{\text{Input (watts)}}$$

- Is incandescent or fluorescent lighting more efficient?

Refrigerator-Freezer
Capacity: 23 Cubic Feet

(Name of Corporation)
Model(s) AH503, AH504, AH507
Type of Defrost: Full Automatic

ENERGYGUIDE

Estimates on the scale are based on a national average electric rate of 4.97¢ per kilowatt hour.

Only models with 22.5 to 24.4 cubic feet are compared in the scale.

Model with lowest energy cost
\$68

\$91

THIS MODEL

Estimated yearly energy cost

Model with highest energy cost
\$132

Your cost will vary depending on your local energy rate and how you use the product. This energy cost is based on U.S. Government standard tests.

How much will this model cost you to run yearly?

		Yearly cost
		Estimated yearly \$ cost shown below
Cost per kilowatt hour	2¢	\$36
	4¢	\$73
	6¢	\$109
	8¢	\$146
	10¢	\$182
	12¢	\$218

Ask your salesperson or local utility for the energy rate (cost per kilowatt hour) in your area.

Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

EPA Form No. 410-107

Researching Energy Topics*



Introduction

We're living in the Age of Information, but it isn't always easy to find the exact information you need. No one wants to rummage for hours among shelves of books and stacks of magazines looking for just the right fact or figure. The library has tools to help in your search, but you have to know how to use them.

In this activity you will choose an energy topic and practice using two of the most important library research tools.

Energy Research Topics

Electricity	Solar Heating	Ocean Thermal Energy
Fossil Fuels in General	Photovoltaics	Energy Conservation
Oil	Biomass Energy	Nuclear Energy in General
Coal	Wind Energy	Fission
Natural Gas	Hydropower	Breeder Reactors
Renewable Energy in General	Geothermal Energy	Fusion

The Card File

For books, use the card file. In it you'll find books listed by topic, author, and title. You'll be looking at the topic cards.

1. Look for your topic alphabetically. If you don't find it, try wording the topic differently. (For example, if you can't find "Nuclear Energy" try "Nuclear Power," "Atomic Energy," or "Energy, Nuclear.")
2. Go through the cards under your topic, and pick the books whose titles interest you.
3. Copy down the "call number" for each book (the set of numbers and letters in the top left-hand corner of the card.)
4. Find the shelves that have your call numbers and locate the books.

The Reader's Guide to Periodical Literature

For magazines, a monthly "Reader's Guide" is published, listing all the magazine articles from more than 170 popular and scholarly magazines. Articles are listed by topic.

1. Look for the topic alphabetically. Again, if you don't find it, try rewording it, or start with a broader topic ("Nuclear Energy" instead of "Fission").
2. Read the list of articles after your topic, and pick those that interest you.
3. Copy the information on where to find each article. If you don't understand all the abbreviations, check the code in the front of the guide.
4. Find the shelves of back magazines and locate the ones you want.

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List all the books that you find here:

Books

Book Title	Author	Call Number	Publisher	Copyright Date	Number of Pages	Library Where Available

List all the magazine articles that you find here:

Articles

Article Title	Author	Magazine or Journal (including volume and issue)	Date	Pages	Library Where Available

110

104

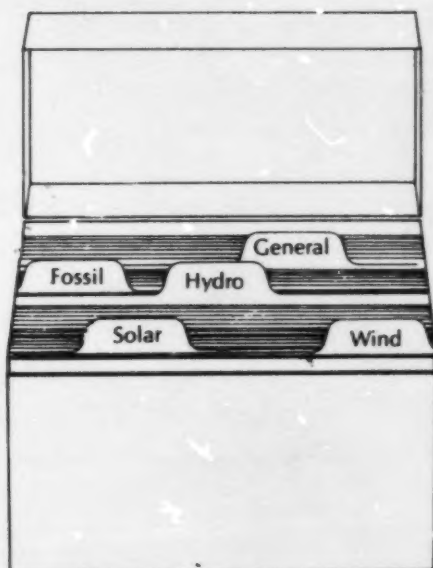
103

You can make a class energy file. Make 3 x 5 cards by duplicating this sample, cutting it out, and folding it in half. Fill out a card for each book or article you read. Blacken in the circle for the appropriate topic or topics.

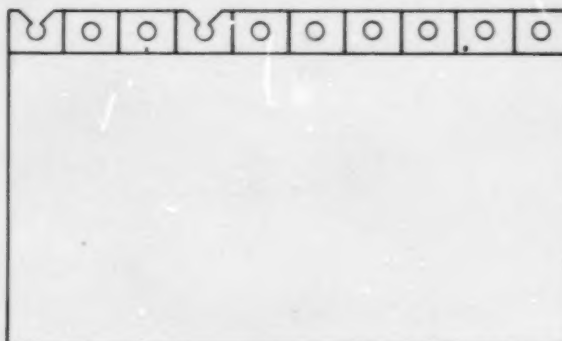
Author(s)	Book	Title	Energy in General	☐
			Electricity	☐
Magazine Article	Date	Magazine Title	Fossil Fuels in General	☐
			Oil	☐
			Coal	☐
			Natural Gas	☐
			Renewable Energy in General	☐
			Solar Heating	☐
			Photovoltaics	☐
			Biomass Energy	☐
			Wind Energy	☐
			Hydropower	☐
			Geothermal Energy	☐
			Ocean Thermal Energy	☐
			Energy Conservation	☐
			Nuclear Energy in General	☐
			Fission	☐
			Breeder Reactors	☐
			Fusion	☐
			Other (specify)	☐

Reading Level	Easy	Average	Difficult
Interest Level	Easy	Average	Difficult
Summary			
Interesting Facts Presented			
Reviewed by			

Organize your cards in a file by topic. . .



. . . Or arrange them alphabetically. Then punch all the circles on each card, and notch the circles you blackened. When you slip a knitting needle through the whole stack, all the cards on one topic will fall out.



I-60. How Much Solar Heat Comes From the Sun?*

(5, 14, 17)

Students can do the following activity to measure the number of calories of solar energy received from the sun per unit area per unit time. Materials needed are: two foam cups, two thermometers, food colors, aluminum foil, graduated cylinder, metric ruler, watch, insulation material (packing foam, crumpled newspaper), cardboard box of same height as cups.

Fill the foam cups with a measured amount of cold water.

Add food colors to one cup.



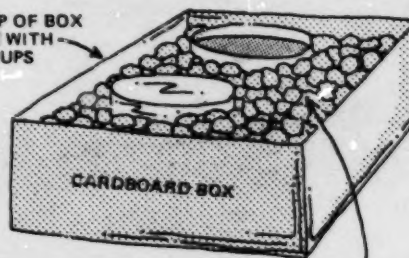
COVER THIS CUP WITH ALUMINUM FOIL TO REFLECT SUNLIGHT.



ADD FOOD COLORS TO H₂O IN THIS CUP TO MAKE THE WATER AS BLACK AS POSSIBLE—THIS ABSORBS SUNLIGHT.

Trim a cardboard box to the same height as the cups. Put the cups in the box and add the insulation material. Put the box in the sun for 10 minutes. (Noon to 1:00 p.m. is usually hottest.) Using a stirring rod, stir the water in the cups, and then use a thermometer to note the temperature.

TOP OF BOX EVEN WITH TOP OF CUPS



PACK INSULATION INTO ALL SPACES AROUND THE CUPS



Do This Calculation:

$$\text{Area} = \frac{\pi d}{4} = \text{square centimeters}$$

$$\text{Calories} = \frac{\text{ml of H}_2\text{O in 1 cup} \times \text{Difference in temperatures of both cups after being in the sun for 10 minutes.}}{\text{Area (square centimeters) of water} \times 10}$$

The "calories" calculation is the amount of solar heat received on 1 square centimeter in 1 minute at your location.

Multiply x 10,000 to get the results for 1 square meter!

- What percentage of the total amount of solar energy is available at your location?
- Would you have enough energy to heat your house if the south side of your roof was covered with solar collectors?

*Adapted from: Solar II: Science Activities in Energy, The American Museum of Atomic Energy, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37830. No.1.

- Can you think of a more accurate way to do this experiment?
- Where do you think most of the errors exist in this experiment?

I-61. A Solar Desalinizer*

(9, 14, 16)

Water is one of our most important resources. In this activity, students will construct a solar desalinizer to be used in separating water from salt by means of solar energy. This process is called distillation.

Materials include:

- plastic shoebox or similar-sized plastic container
- a small paper cup, a small jar, or 50-ml beaker
- salt
- a large rubber band
- a marble or rounded stone
- black construction paper
- 500-ml beaker
- tape

Precautions:

Make sure all equipment is clean, as students will be tasting solutions. Remind students that they should never taste chemicals unless directed to do so by the teacher.

Make sure students do not accidentally contaminate the distilled water with salt water.

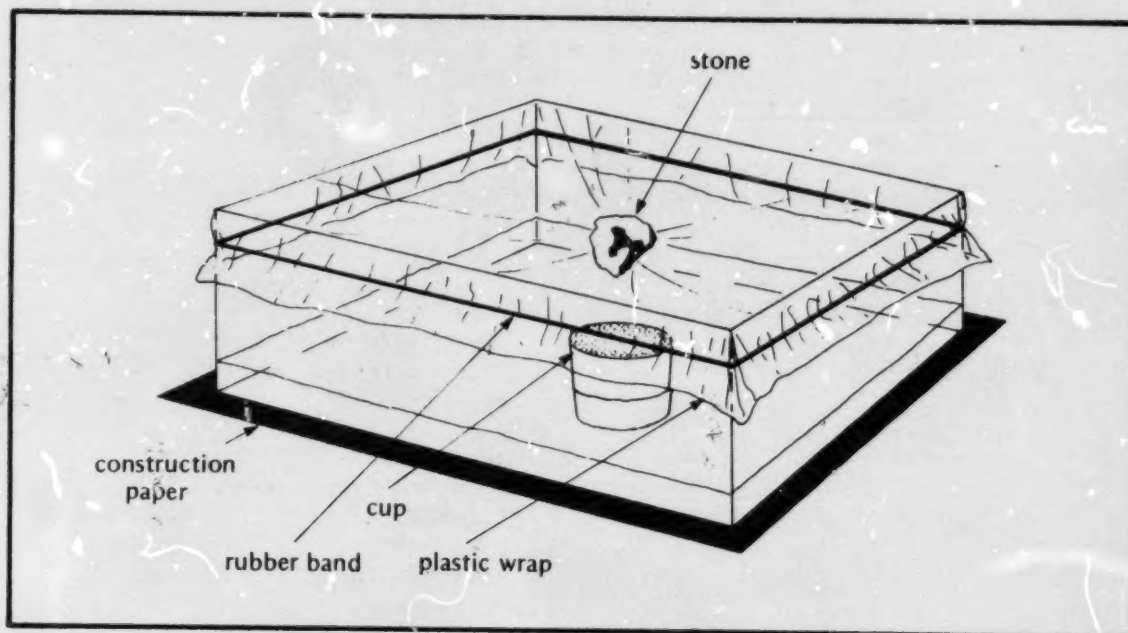
Make sure the plastic wrap does not touch the edges of the cup or the condensate will not drop into the cup.

Before beginning this activity, students could be asked to formulate an hypothesis as to the results and then decide whether their hypothesis was correct.

1. Pour 500 ml of hot tap water into a clean beaker and add a small amount of table salt.
2. Use clean hands to carefully taste the solution by dipping your finger into it and placing it on your tongue. How does the solution taste?
3. Tape the cup or jar into the center of the plastic shoebox.
4. Carefully pour the salt water solution into the shoebox. Be sure not to get any in the cup.
5. Cover the shoebox with the plastic wrap. Hold it in place with the rubber band.

*Reprinted from: Renewable Energy Activities for Junior High/Middle School Science, Solar Energy Project, SUNY at Albany, 1400 Washington Avenue, Box 22425, Albany, NY 12222.

6. Place the marble or stone in the center of the plastic wrap, directly above the cup. Press down on the marble and loosen the wrap so that the marble sits in a depression, but not so far down that the plastic wrap touches the rim of the cup.



7. Carry the equipment to a level spot in direct sunlight, being careful not to slosh salt water into the cup. Set the black construction paper down first, then place the shoebox on top. Predict what you think will happen in your solar desalinizer.
 8. Observe your solar desalinizer at intervals during the day. What is happening?
 9. When your teacher directs you to, uncover the shoebox and carefully remove the cup. Dry the outside. Be sure not to get any salt solution into the cup. What does the cup contain? Taste the contents using the method already described. Again, taste the solution in the shoebox.
- What did you predict would happen when your desalinizer was placed in the sun?
 - What actually did happen inside your desalinizer? What is this process called? Was your prediction correct?

I-62. The Greenhouse Effect*

(9, 12, 16)

One of the fascinating things about solar energy is the way it changes from light to heat. This change takes place when light falls on a surface which absorbs its energy. The absorbing surface warms up from the absorbed energy and begins to give off heat. What happens next will be shown in this activity. Materials needed are:

- two Celsius thermometers
- two clear plastic shoeboxes
- a clear plastic cover for one shoebox (or plastic wrap)
- an outdoor reflector flood lamp, mounted on a ringstand
- soil
- water
- cardboard
- a watch, clock, or timer to measure seconds

Precautions:

Remind students not to touch the flood lamps. Stress the need to take the same precautions with flood lamps as with any electrical device.

Make sure that the lamps do not melt the plastic boxes.

Position set-ups away from direct sunlight, open windows, and heating or cooling system vents

Follow the procedures below:

1. Cut out a piece of cardboard so that, when it is inserted into one of the clear plastic shoeboxes, it will divide the box in half and will be only about three-fourths the height of the box (Diagram 1). Construct a second cardboard support for the other box.
2. Place soil to a depth of 2 cm in each of the shoeboxes. Thoroughly moisten the soil with water, but not so much that water sits on top of the soil.
3. Insert a cardboard support into each shoebox.
4. Lean a thermometer (with the bulb end up) against each support (Diagram 2).

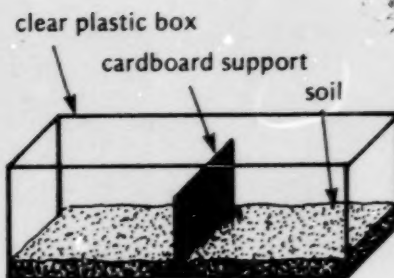


Diagram 1

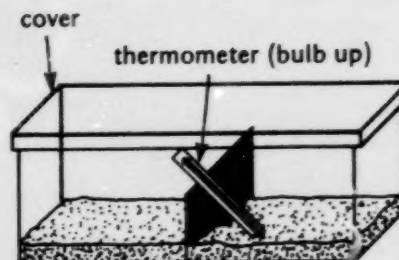
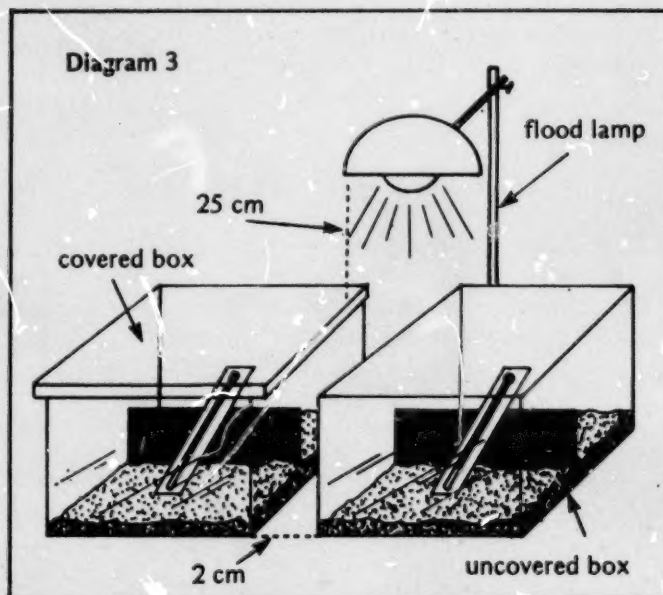


Diagram 2

*Reprinted from: Renewable Energy Activities for Junior High/Middle School Science, Solar Energy Project, SUNY at Albany, 1400 Washington Avenue, Box 22425, Albany, NY 12222.

5. Set the boxes side by side and about 2 cm apart under the flood lamp. Adjust the flood lamp so that it is above and equally distant from each box (Diagram 3). Place a clear plastic cover on one box.

(**Caution:** Locate your set-up away from direct sunlight or drafts from windows and heating or cooling systems, all of which may produce convection currents that could interfere with the activity).



6. When the temperatures of the thermometers stop changing, record them on a data table.
7. Formulate a hypothesis regarding the temperature of covered vs. uncovered boxes.
8. Turn on the light. Read and record the temperature of each thermometer ever 30 seconds for 15 minutes. Turn off the light.
9. Plot the data from each shoebox on a graph. Be sure to label each line correctly with "covered shoebox" or "uncovered shoebox."
- (**Caution:** Do not touch the flood lamp since it may become very hot. Do not look directly at the lamp either).

Discussion can include summary of data, whether or not hypothesis was supported, the covered box as a model for the Earth and its atmosphere.

- What was the total temperature change of the air in the uncovered box?
- In which box did the temperature change more? By how many degrees more?
- How did covering one box affect the rate at which the temperature changed in that box?
- Discuss the applications of the greenhouse effect in terms of heating buildings with solar collectors, passive solar, and attached greenhouses.

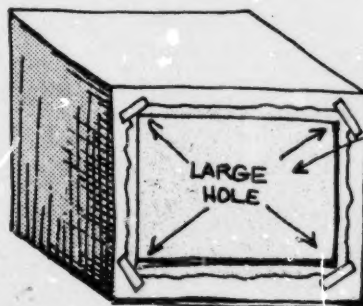
I-63. Orientation of a House and Solar Energy

(9, 13, 16)

Passive solar designs take advantage of such factors as the way a house is oriented. Have students predict how effective they think window location is in heating a home and then conduct an experiment to test their hypotheses. Materials include:

- two cardboard boxes of the same size
- white paint or paper
- two thermometers
- plastic wrap
- masking tape

1. Cut a hole in one side of each box and cover it with plastic wrap. Tape it tightly all around.
2. Paint both boxes white or cover them with white paper.
3. Place a thermometer in each box and put the boxes in the sun so that one box has its window facing the sun and the other box has its windows in the shade.
4. Record the temperature at various intervals and graph the results.



Students should discover that the box with the window facing the sun got warmer. A discussion of the results could lead students to try other activities with their "cardboard box houses," such as: comparing the effects of heating at different times of the day, on cloudy and sunny days, at different times of the year. Students could also try modifying their boxes to improve upon the heating effect.

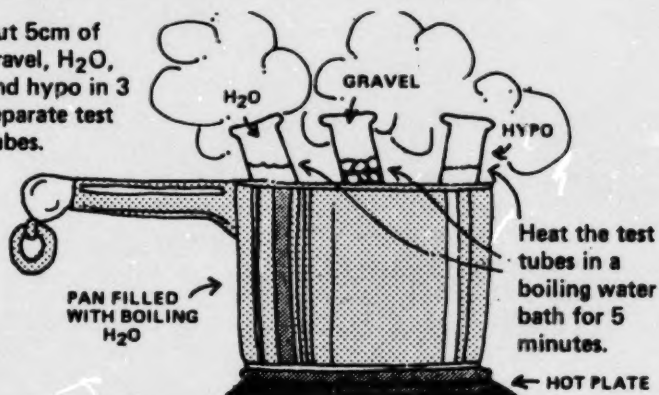
I-64. Materials that Store Heat*

(9, 14, 16, 17)

By heating and then observing heat loss, students investigate three materials used to store heat in solar systems. Materials required are:

- hot plate, pan or beaker
- three large test tubes
- three thermometers
- three styrofoam cups
- equal volumes of three materials: gravel, water, and hypo or hydrated sodium thiosulfate (Glauber's salt, another hydrated salt, is used in some solar storage systems.)

Put 5cm of gravel, H_2O , and hypo in 3 separate test tubes.



*Adapted from: Solar II: Science Activities in Energy, The American Museum of Atomic Energy, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge TN 37830. No.7.

Fill the styrofoam cups with equal, measured amounts of cold water. Record the water temperature.

- Predict which materials will give up the most heat and which the least heat.



Add the test tubes, one to each cup. In 15 minutes record the temperatures again. Calculate the number of heat calories gained by the H₂O.

Water temperature after 15 minutes: H₂O _____ Hypo _____ Gravel _____
 $C = \text{Mass of Water (grams)} \times \text{Difference in temp. before and after (}^{\circ}\text{C)}$

- Which substance gives up the most heat? Was the hypothesis supported?
- What are the advantages and disadvantages of each storage method?

I-65. The Solar Cell

(5, 12, 14)

Obtain some of the silicon-type solar cells and hook into an appropriate voltmeter-ammeter circuit. Have the students calculate the power output of the battery at different times of the day, at different angles to the Sun, or with incident light of similar intensity and spectral fidelity to the Sun.

- Calculate the costs for sufficient solar cells to meet a typical electrical consumption bill for your home.
- Calculate the area in square meters that the solar cells would require when installed.
- What are the advantages of solar cell-produced electrical energy?
- What are the disadvantages?
- Assuming that storage batteries could be installed in a home to hold energy for cloudy weather, what problems remain in installing solar cells for home energy supply?

I-66. The Leaf as Solar Collector*

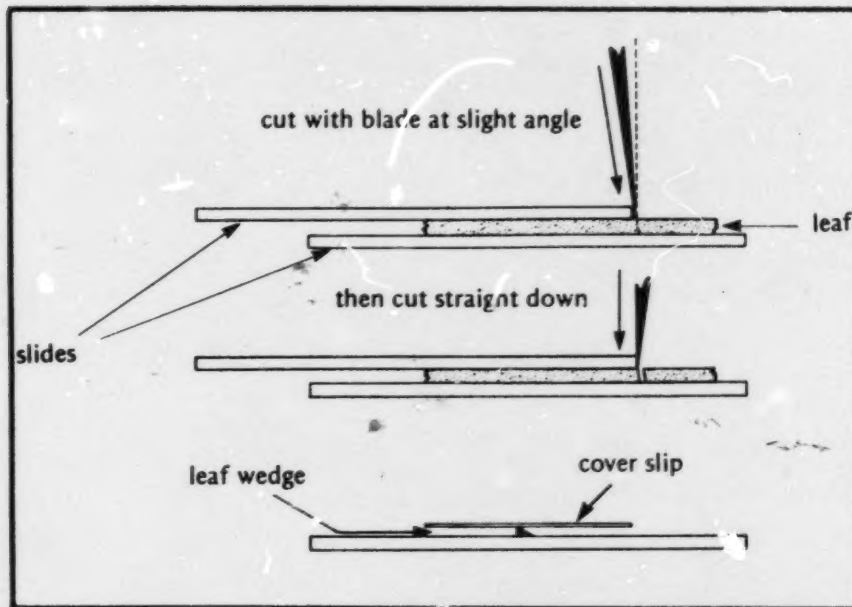
(1, 2, 4, 14)

In this activity students compare the leaf with a manufactured solar collector. They find that, while there are many structural similarities,

*Reprinted from: Renewable Energy Activities for Biology, Solar Energy Project, SUNY at Albany, 1400 Washington Avenue, Box 22425, Albany, NY 12222.

the collector produces heat energy and stores it in the water or sand while the leaf produces chemical energy and stores it in stem, root, and fruit. In addition, a collector is tight while a leaf has openings for gas exchange and cooling. Gather the following materials and conduct the activity below with the class.

- a fresh leaf from the plant Ligustrum (Privet)
- one cover slip
- three microscope slides
- one single-edged razor blade
- a compound microscope
- drawing paper
- eyedropper



1. Place your leaf between two microscope slides as shown in the diagram. Move the top slide back so that part of the leaf is exposed.

2. Using your razor blade (Caution: Use carefully.) slice a portion of the leaf along the edge of the upper slide at a slight angle.

3. Now make another slice perpendicular to the lower slide. This will produce a wedge of tissue suitable for microscopic observation.

4. Repeat steps 2 and 3 several times in order to produce several wedge-shaped cross sections. Place these sections in a drop of water on the center of a third microscope slide. Add a cover slip to your wet mount.
5. Place your wet mount on the stage of a compound microscope and view under low power. Find part of a leaf section thin enough to study and center it in your field of view.
6. Under the microscope locate and draw the following tissues of the leaf.
- a. Upper Epidermis: These small, thick cells on the upper surface of the leaf protect the inner tissues from mechanical injury and help prevent the loss of water. In many plants, a waxy cuticle covers the upper epidermis, further preventing water loss. The epidermis allows sunlight to pass through it.

- b. Mesophyll: This tissue lies between the upper and lower epidermis and contains the cells which use sunlight to manufacture food by photosynthesis. There are two distinct layers. Palisade mesophyll cells are long and cylindrical, lying in a tightly packed layer just below the upper epidermis. Spongy mesophyll cells are irregularly shaped cells lying below the palisade layer in a more loosely packed arrangement with many air spaces between them. Both types of mesophyll cells contain chloroplasts, the small green bodies which contain chlorophyll and where photosynthesis occurs. Be sure to include these structures in your drawing.
- c. Veins: Within the mesophyll tissue, you will see circular groups of smaller cells which lack chloroplasts. These are cross sections through the veins of the leaf. Veins contain cells which transport water and minerals to the leaf or transfer the food produced to other parts of the plant.
- d. Lower Epidermis: Try to find openings in this lower surface layer where gases are exchanged between the leaf and the atmosphere.
- Which leaf tissue serves as a natural glazing for light absorption? What properties help to make it an effective transmitter of solar energy?
 - In which tissue of the leaf is more of the light absorbed?
 - What is the color of the absorption layer of the leaf? What structures give this layer its color? What does this color indicate about the colors of light absorbed by the plant? What color of light is reflected by the plant?
 - In what way does the plant leaf use the energy from sunlight differently than does the manufactured solar energy collector?
 - The leaf usually remains cooler than a manufactured solar energy collector. What factors might be responsible for this difference in temperature?
 - What is the function of the open spaces in the leaf? How do these openings make the leaf different from the manufactured solar energy collector?
 - Both the plant leaf and the manufactured solar collector have an energy transfer system. Describe each system and indicate the similarities and differences existing between them.
 - Both the plant leaf and the manufactured solar collector have a storage system. In what form does each store energy? How does the plant call upon the stored energy when it is needed? What about the manufactured collector system?

I-67. Waste: How Much Is There?

(5, 12, 15)

Waste accumulation is a problem in many households. The amounts of waste generated in a home can be tremendous. Have students determine the weight of all family trash and/or garbage collected over the period of a week. Have them use the resultant information to do the following:

1. Determine trash weight per person by dividing the weight of trash by the number of persons living in the household.
2. Compare your results to those of the other class members and note any significant differences. If differences do exist, try to identify the reasons for them.
 - How much trash would be generated in a year by each person and by all occupants if the trend you recorded was to continue?
 - How much trash, per week and per year, would be generated in your community if everyone contributed the same as each member of the household? How much trash would the State and the Nation have to deal with?
 - Suggest ways for reducing the quantities of trash produced in this country.
 - Comment on the advantages and disadvantages of an intended solution such as container legislation.

I-68. Wind Power for Your Home*

(5, 9, 13, 15, 17)

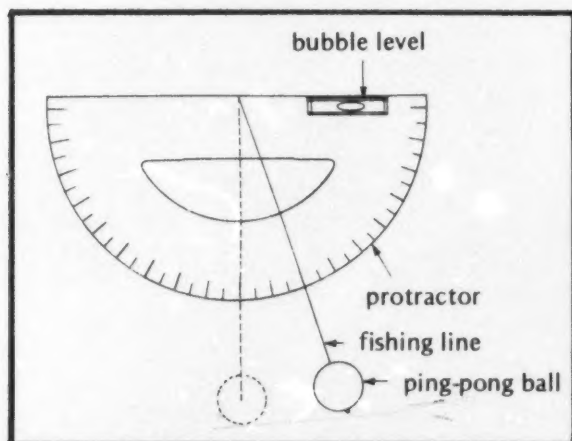
Wind can be a viable energy source to people in suitable locations. Have students perform the activity to determine whether or not their homes are in localities which could benefit from wind power. Necessary materials include:

- ping-pong ball
- 30-cm long piece of monofilament fishing line
- protractor
- bubble level
- needle (longer than the diameter of the ping-pong ball)
- red magic marker
- glue

(Cautions: If students are going to inspect appliances for their power ratings, they should be reminded to first unplug them.)

Stress that collection of wind data over only one day does not yield valid information on average annual wind speed or the suitability of wind power for a particular site.)

*Reprinted from: Renewable Energy Activities for Junior High/Middle School Science, Solar Energy Project, SUNY at Albany, 1400 Washington Avenue, Box 22425, Albany, NY 12222.



1. Construct the wind-speed indicator as shown in the diagram.

- Color the fishing line with the magic marker.
- Glue the bubble level on the protractor as shown.
- Thread the needle with the colored fishing line and push it through the ping-pong ball.
- Remove the needle from the fishing line. Knot the end of the fishing line and glue it to the ping-pong ball.
- Glue the other end of the fishing line to the center of the protractor as shown.

- Choose an open site near your home. Holding your indicator so that the bubble of the level is centered, face into the wind and record the angle that the fishing line makes with the horizontal plane of the protractor. Take measurements of this angle at four different times: 8:00 A.M., 12:00 Noon, 4:00 P.M., and 8:00 P.M. Record each measurement. Add these values and divide by four to determine the average angle of the fishing line. Record this value.
- From Appendix B-12, choose the angle closest to your average angle. Record the wind speed determined by this angle.
- Using Appendix B-7, determine the average wattages of home electrical appliances in use in your home at a time when the fewest number of appliances are in operation. Copy their wattages. This is known as your home's base load. Then determine the appliances in use at a time when the greatest number of appliances are in operation and record their wattages. This condition is known as your home's peak load.

(If more than one of any appliance is in use at either time, multiply the wattage by the number in use before recording it.)

Add each set of data to determine the total wattage for each condition of use.

- Appendix B-13 indicates the wattages provided by propeller-type wind generators of varying diameters for several wind speeds. Select the wind speed which is at or just below the value found for your home site. From the wattages given under that wind speed, determine the number and diameter of wind generators which would supply first the base and then the peak load requirement of your home.

For example, if your wind speed were 16 km/hr. and your home's base

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load requirement were 325 watts, then you would need one 5.5 m diameter wind generator, or two 3.6 m diameter wind generators to meet your home's requirement.

Record your choices.

Find out the average annual wind speed for your area. Try your local weather station or university science department. Repeat Step 5 for this wind speed.

- If your area would seem to be suitably situated to benefit from wind power, make a list of the advantages and disadvantages of using that form of energy.

I-69. Wind Speed - The Beaufort Scale

(1, 2, 14)

Students should use the Beaufort Wind Scale provided as another means of determining whether or not there is sufficient wind in their locale to generate electricity. (Any wind over 8 miles per hour would be sufficient.) Such variables as time of day and siting should be made a part of the activity.

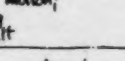
I-70. Taking the Earth's Temperature* (9, 12, 14, 22)

A can of sand heated on a hot plate is a model of the Earth's crust. Students learn that the Earth's crust contains a potential energy source. Materials include:

- 1-gallon can or other suitable container
- sand—enough to fill the can
- 300-watt bulb or heat lamp
- thermometer—0° to 100°C and long enough to reach the bottom of the can
- metric ruler or meter stick
- cardboard box large enough to hold the can
- scissors

Prepare the activity by collecting the materials and running through the experiment in the following manner:

* mph = miles per hour

Beaufort number	Description*	Observation
0	calm (0-1 mph)	smoke rises vertically 
1	light air (2-3 mph)	smoke drifts slowly 
2	slight breeze (4-7 mph)	leaves rustle; windchime moves 
3	gentle breeze (8-12 mph)	twigs move; flags extended 
4	moderate breeze (13-18 mph)	branches move; dust and paper rise 
5	fresh breeze (19-24 mph)	small trees sway 
6	strong breeze (25-31 mph)	large branches sway; wires whistle 
7	moderate gale (32-38 mph)	trees in motion; walking difficult 
8	fresh gale (39-46 mph)	twigs break off trees 
9	strong gale (47-54 mph)	branches break; roofs damaged 
10	whole gale (55-63 mph)	trees snap; damage evident 
11	storm (64-72 mph)	widespread damage 
12	hurricane (73-82 mph)	extreme damage 

Adapted from: Wind: Science Activities in Energy, The American Museum of Atomic Energy, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37830. No.1.

Before class, heat the cans of sand on a hot plate for 5-10 minutes each to get the bottom sand to a temperature of between 75°C and 100°C. Put each hot can of sand in a box so that the students will not know it has been heated. Be sure that the can is not so hot that it scorches the box. You may want to wrap some cardboard or insulation around the bottom of the can so that the students do not discover that it has been heated. If this experiment is to be done in successive classes, some arrangement must be made to reheat the sand between classes. Since the students have finished working with the sand about halfway through the period, the cans may be removed at that time and reheated. Two or three groups of students may use the same can to collect their data.

1. Set up the can of sand, box, and light as shown in the diagram.

2. Adjust the light source so that it is about 30cm above the sand.

3. Turn on the light and heat the sand for 15 minutes.

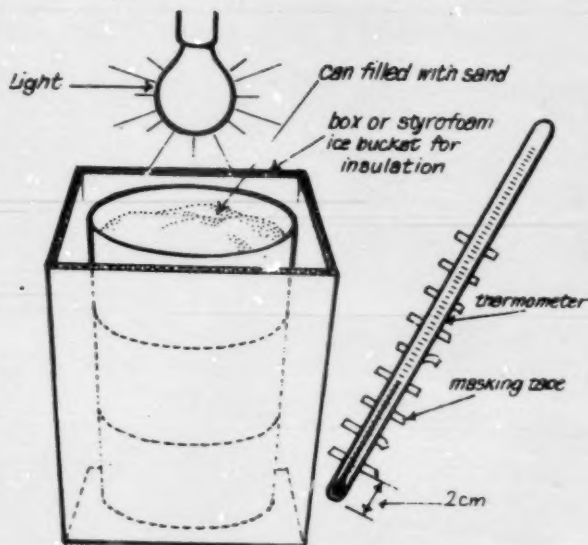
4. While the sand is heating, start at the bulb end of the thermometer, and use pieces of masking tape to place marks on the thermometer every 2cm. Do not put the tape over the scale of the thermometer.

5. Formulate a hypothesis relating temperature to depth.

6. After 15 minutes, remove the light source and take the temperature of the sand at the surface. Then push the thermometer down 2cm into the sand, let the temperature adjust, and record the temperature on the table below. Continue to take the temperature at 2cm increments to the bottom of the can.

7. Plot the depth and temperature on a graph.

8. Evaluate your hypothesis.



At this point, inform students of the advance preparation that was done.

The following data were taken from a well, similar to an oil well, drilled 8km into the Earth's crust. Graph these data also.

Depth km	Temp °C
0	15°
1	51
2	88
3	120
4	151
5	179
6	205
7	232
8	257

Students should understand that the heat in the sand is not coming from the light bulb. Point out that you preheated the sand. Discuss the Earth's "hot plate" below the crust and the heated sand as a model for the Earth's crust.

I-71. Steam from Hot Rocks (Teacher Demonstration)

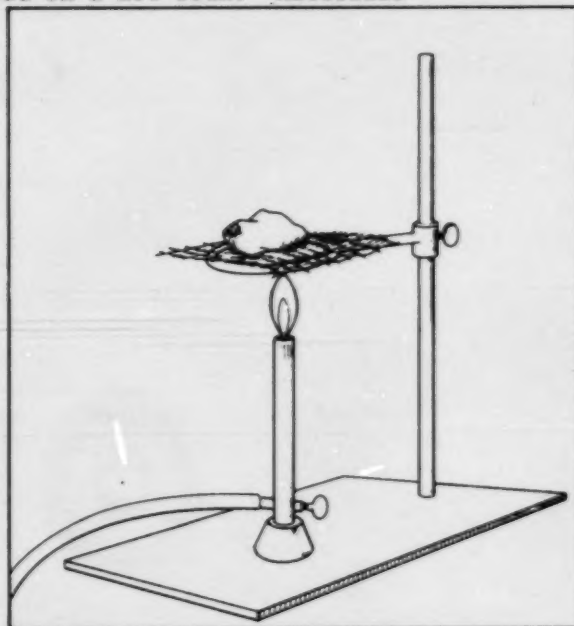
(1, 14, 15)

Geothermal energy is energy produced as a result of the Earth's heat. Geysers and hot springs, manifestations of geothermal energy, are evidence that hot rocks will boil water, producing steam. Have students observe what happens when water is dropped on a hot rock. Materials include:

- a rock that can be safely heated (i.e., granite)
- bunsen burner, ring stand
- eyedropper
- safety glasses
- wire gauze
- beaker of water

(Caution: Safety glasses must be worn.)

1. Set up the equipment as illustrated.
2. Put on safety glasses.
3. Heat the rock for five minutes.
4. Remove the heat source.
5. Using an eyedropper of water, carefully put one or two drops of water on the rock.



Students should observe the water boiling and producing steam. They should be able to relate this observation to the nature of geothermal energy.

I-72. The Tides in the Bay of Fundy*

(2, 5, 14)

Students simulate the actions of the tides in the Bay of Fundy. Materials required are: 2 beakers (250 ml and 400 ml), water and a marking pencil.

1. Label the 400 ml beaker "Ocean" and the 250 ml beaker "Bay of Fundy."
2. Place about 200 ml of water in the "Ocean" beaker. Measure the height of the water. Record the height. [Height _____ cm]
3. Now, just as the tides come into the Bay of Fundy two times a day, pour the ocean water into the "Bay of Fundy" beaker.
4. Measure and record the height of the water. [Height _____ cm]

This represents the tide coming into the Bay of Fundy.

*Adapted from: Canada, Mexico, and the United States: Energy Mix or Mix-up?, (unpublished draft), National Science Teachers Association, Washington, D.C., page 67.

5. Pour the water back out into the 400 ml "Ocean" beaker.
This represents the tide going out.

Discuss the need for a narrower beaker to represent the Bay of Fundy, and its implications for tidal power facility siting.

I-73. Electrolysis of Water (Teacher Demonstration) (1, 14, 15)

Fuel cells make use of the ionization of hydrogen and oxygen to produce electricity. Water (H_2O) is the resultant product. To demonstrate the interrelationship of electricity to the chemical energy in hydrogen, oxygen, and water, have students observe the electrolysis of water. Materials needed include:

- Hoffman apparatus
- water
- sulfuric acid
- 6-volt energy source

(Caution: This should be a teacher demonstration. Safety glasses should be worn. When mixing acid with water, always add the acid to the water.)

Discuss the fact that electrical energy was used to decompose water into hydrogen and oxygen. Since chemical actions are reversible, the synthesis of water could involve the production of electricity. In fact, this is the case in the fuel cell.

APPENDIX B — RESOURCES

1. Energy Unit Conversions

The following table* relates the four basic units of energy

Energy Conversion factors	Value in joules	Value in kilowatt-hours	Value in BTUs
1 joule	1	(2.78) (10^{-7})	(0.95) (10^{-3})
1 kilowatt-hour	(3.6) (10^6)	1	(3.41) (10^3)
1 calorie	4186	(1.16) (10^{-3})	3.97
1 BTU	1055	(2.93) (10^{-4})	1

2. Oil-Based Products

antenna table	card tables	car sound insulation
credit cards	ping pong paddles	garment bags
permanent-press clothes	purses	fences
heart valves	weed killers	kitchen counter tops
crayons	football pads	pillows
disposable diapers	puzzles	dune buggy bodies
parachutes	carbon paper	checkers
telephones	dishdrainers	soap dishes
enamel	puppets	syringes
transparent tape	upholstery	shoes
vinyl siding	hearing aids	volleyballs
safety flares	earphones	sleeping bags
bubble bath	whistles	electrician's tape
bookends	clothesline	mascara
deodorant	carpet sweepers	flags
panty hose	chess boards	oxygen masks
bedspreads	yardsticks	ink
plastic tubs	slip covers	hair spray
shag rugs	patio screens	steering wheels
lunch boxes	mats	food wraps
windshield wipers	refrigerator linings	rubber duckies
phonographs	floor wax	seed tape
lamp shades	panelling	mailboxes
skateboard wheels	tents	uniforms
guitar strings	finger paints	pacifiers
jugs	glycerin	cassette tapes
eyeglasses	foot pads	luggage
vinyl tops	lamps	antifreeze
TV cabinets	ice cube trays	flashlights
measuring tape	swimming pool liners	motorcycle helmets

*From: Energy Conservation in the Home, United States Department of Energy, Washington, D.C., October, 1977.

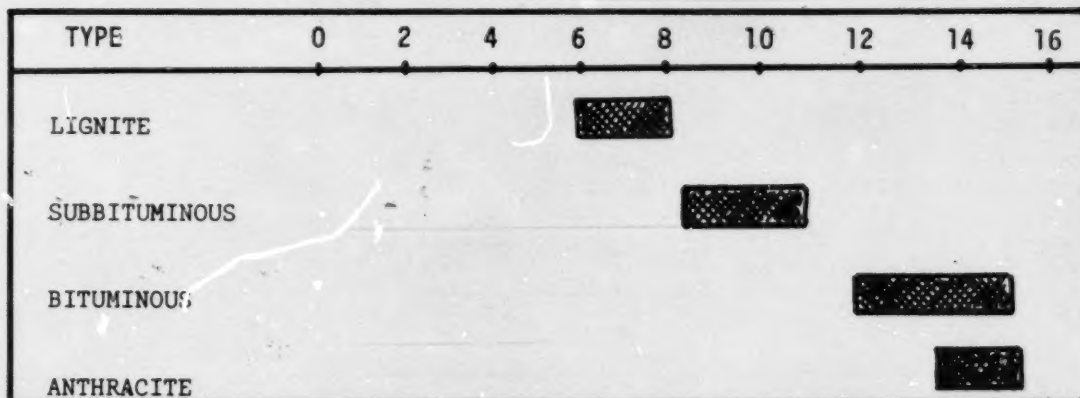
water softeners
microfilm
tennis balls
measuring cups
dishwashing liquid
extension cords
earrings
false eyelashes
no-wax floors
golf balls
lighter fluid
attache cases
wet suits
laxatives
trash cans
brassieres
acrylic paints
vacuum bottles
bearing grease
rafts
sockets
tiles
air conditioners
wallets
backpacks
rubbing alcohol
epoxy glue
oil filters
gaskets

cough syrup
hair dryers
styrofoam coolers
brake fluid
draperies
car battery cases
hockey pucks
fertilizers
knitting yarn
sandwich bags
tablecloths
toothbrushes
notebooks
darts
flea collars
stadium cushions
hang gliders
sandals
lipstick
electric blankets
digital clocks
life jackets
model planes
insect repellent
fishing nets
hair coloring
rubber cement
computer tape
ammonia

antibiotics
shower doors
sugar bowls
decoys
tobacco pouches
pencils
model cars
garden hoses
lawn sprinklers
playing cards
dolls
bubble gum
coasters
straps
tires
rulers
boat covers
unbreakable dishes
toothpaste
combs
plastic varnish
badminton birdies
bird feeders
hair curlers
laminates
visors
tennis rackets
canisters
venetian blinds

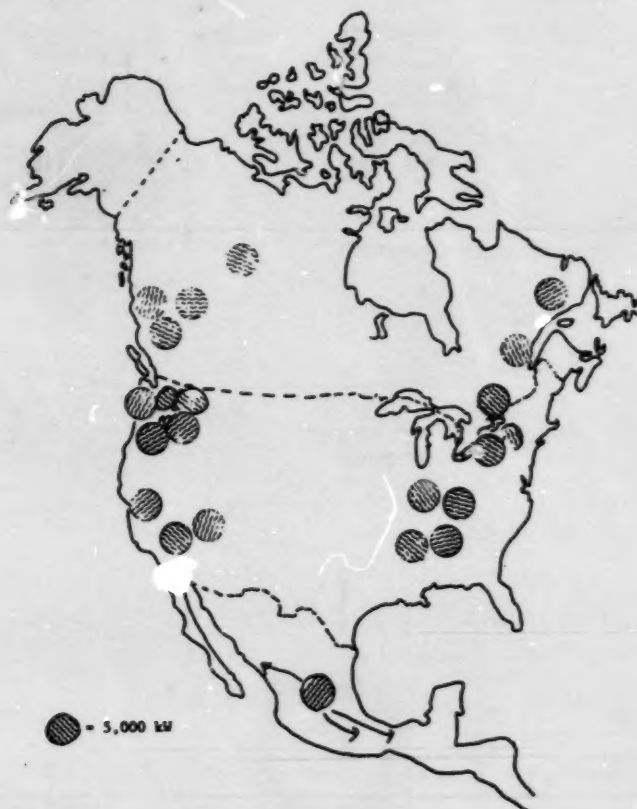
3. Heat Content of Major Coal Types

Heat Content of Major Coal Types*
(in thousands of BTU's per pound).



*From: Energy Alternatives, A Comparative Analysis, Figure 1-3,
Environmental Policy Center, 317 Pennsylvania Avenue, S.E., Washington,
D.C., 20003, February 1975.

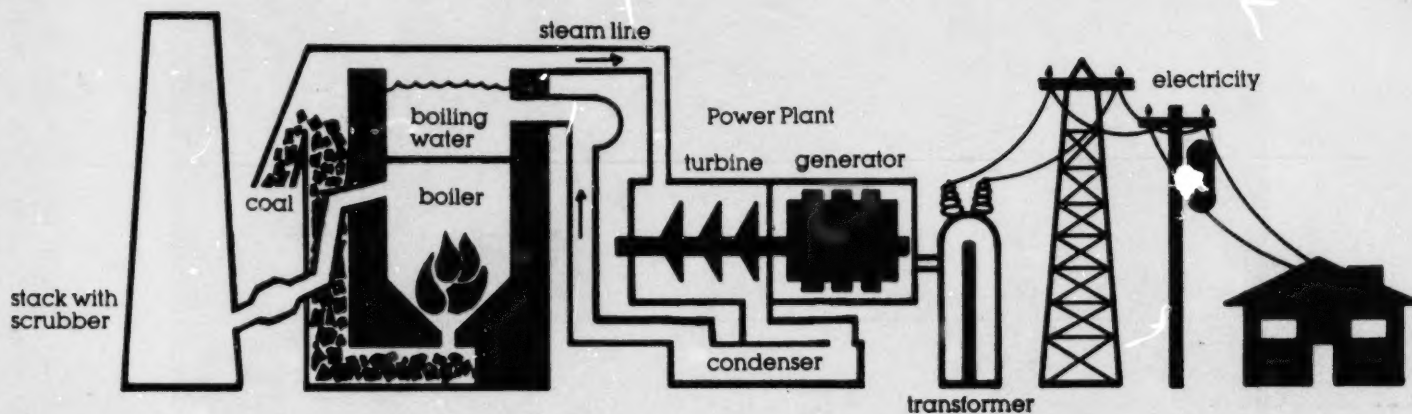
4. Installed Hydroelectric Capacity*



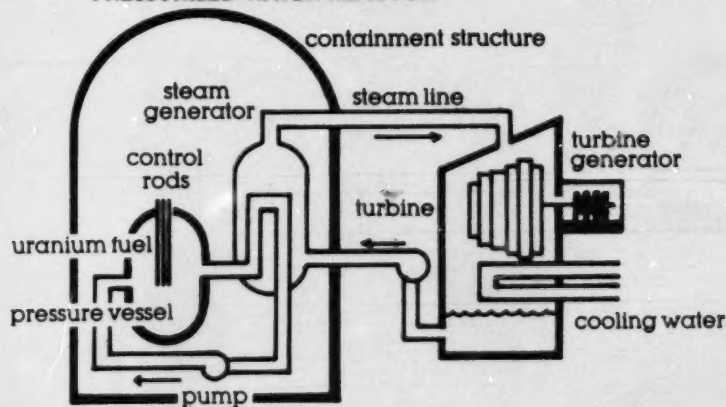
*Adapted from: Canada, Mexico, and the United States: Energy Mix or Mix-up?, (unpublished draft), National Science Teachers Association, Washington, D.C., page 67.

5. Electricity Production*

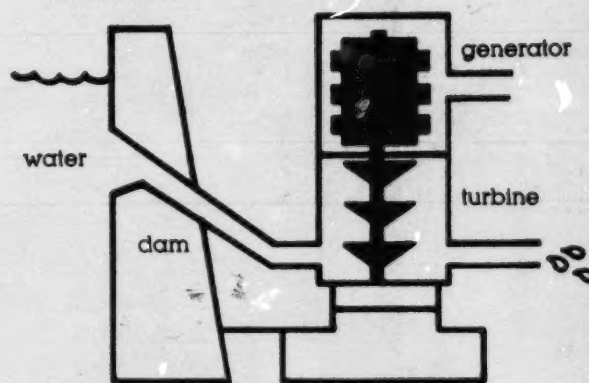
FOSSIL FUEL (COAL)
POWER PLANT



NUCLEAR POWER PLANT —
PRESSURIZED WATER REACTOR



HYDROELECTRIC
POWER PLANT



*Reprinted with permission from: Energy Adventure, AMOCO Educational Services, Chicago, Illinois.

6. Thermostat Setting Savings*

A significant savings in heating and cooling costs can be achieved through proper use and placement of thermostats. In a study sponsored by the National Science Foundation and the Energy Research and Development Administration, it was shown that very minor reductions in thermostat settings (from 72 to 68 degrees) in all U.S. homes during the heating season could result in a savings of 2.3 percent of the nation's total energy consumption. Additional nighttime setbacks to 55 degrees could bring the total savings to 4.1 percent of the nation's total energy consumption.

Nighttime setbacks can be made manually or a clock-actuated device can be added to central systems. The clock-actuated thermostat automatically changes the thermostat between two settings at predetermined times, permitting the temperature to be automatically reduced at night. The device costs approximately \$70 and is easily installed on existing systems. An electric blanket may add comfort when practicing nighttime setback, but do not let it remain on when not in use.

The United States Department of Energy predicts that setting thermostats no lower than 78 degrees could result in reductions in home cooling costs up to 47 percent. The National Bureau of Standards recommends increasing the thermostat setting even more during peak cooling load periods which may reduce costs by an additional 15 percent.

Although the savings vary from area to area, in general a reduction in the thermostat setting for heating results in a savings of approximately three percent for each degree. Each degree of increase in the thermostat setting for cooling results in a savings of approximately five percent per degree. The newly recommended setting for the heating season is 65 degrees.

In addition to thermostat setbacks, proper location of thermostats affects energy consumption. The thermostat location should allow the instrument to sense temperature changes representative of the entire area to be heated or cooled. In general, thermostats should be located on an interior wall away from drafts, appliances, direct sunlight, and fireplaces. Draperies and furniture should not interfere with or block the thermostat.

In many cases a single thermostat is not sufficient. Zone control -- independent temperature control for each area to be heated and cooled with appropriate distribution control (components to direct water or dampers to direct air) -- has several advantages. First, fuel can be saved since only those areas occupied are heated or cooled. Second, quicker response to temperature change is possible. And finally, comfort in sleeping and living areas can be individually controlled for desired temperatures. Tests have shown that zoning can achieve energy savings of at least 20 percent.

*Adapted from: Energy Conservation in the Home, p. 96, United States Department of Energy, Washington, D.C., October, 1977.

7. Annual Energy Requirements of Electric Household Appliances

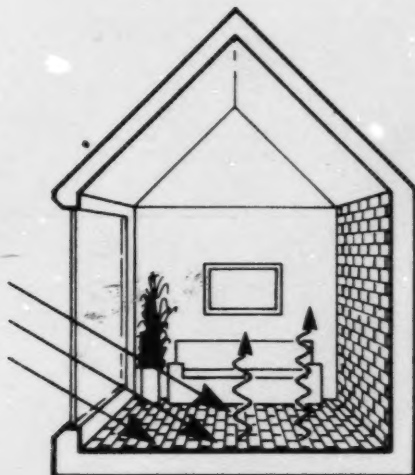
(NOTE: kwh = Kilowatt-hour
= 1,000 watts/hour)

APPLIANCES	AVERAGE WATTAGE	ANNUAL kwh CONSUMPTION
Air cleaner	50	216
Air conditioner (room)	997	1,032*
Bed covering	177	147
Blender	386	15
Broiler	1,436	100
Carving knife	92	8
Clock	2	17
Clothes dryer	4,856	993
Coffee maker	894	106
Dehumidifier	257	377
Dishwasher	1,201	363
Fan (attic)	370	291
Fan (circulating)	88	43
Fan (window)	200	170
Floor polisher	305	15
Freezer (15 cu. ft.)	341	1,195
Freezer, frostless (15 cu. ft.)	440	1,761
Hair dryer (hand held)	381	14
Heater (portable)	1,322	176
Heating pad	65	10
Hot plate	1,257	90
Humidifier	177	163
Iron	1,008	144
Mixer	127	13
Oven (microwave)	1,450	190
Radio	71	86
Radio/record player	109	109
Range	12,200	1,175
Range (self-cleaning)	12,200	1,205
Refr./Freezer (14 cu. ft.)	326	1,137
Refr./Freezer, frostless (14 cu. ft.)	615	1,829
Roaster	1,333	205
Sewing machine	75	11
Shaver	14	1.8
Television (bw) tube type	160	350
Television (bw) solid state	55	120
Television (c) tube type	300	660
Television (c) partial solid state	200	440
Toaster	1,146	39
Toothbrush	7	0.5
Vacuum cleaner	630	46
Washing machine (automatic)	512	103**
Washing machine (manual)	286	76
Waste disposer	445	30
Water heater (standard)	2,475	4,219
Water heater (quick-recovery)	4,474	4,811

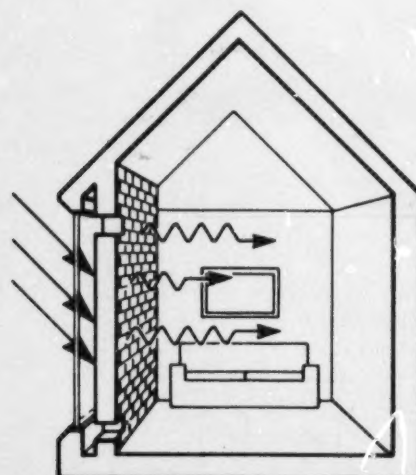
*Based upon 1,000 hours of operation per year. This figure will vary widely depending on geographic area and size of unit.

**Does not include kilowatt-hours for heating water.

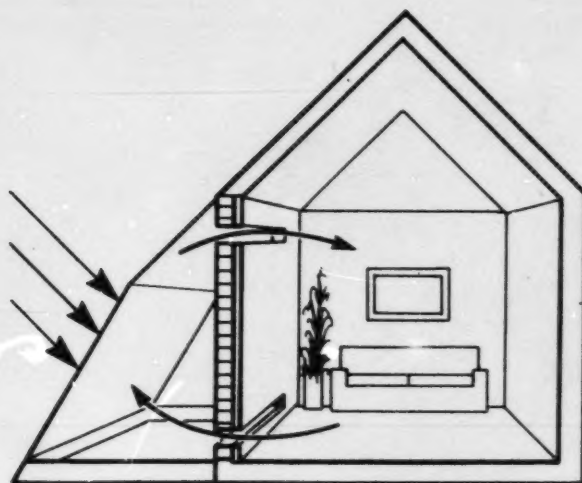
Passive Solar Systems*



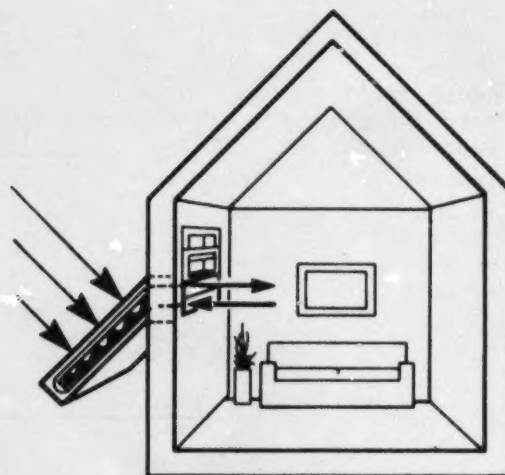
Direct Solar Gain



Indirect Solar Gain
(with Trombe wall)



Isolated Solar Gain
(with sunspace)

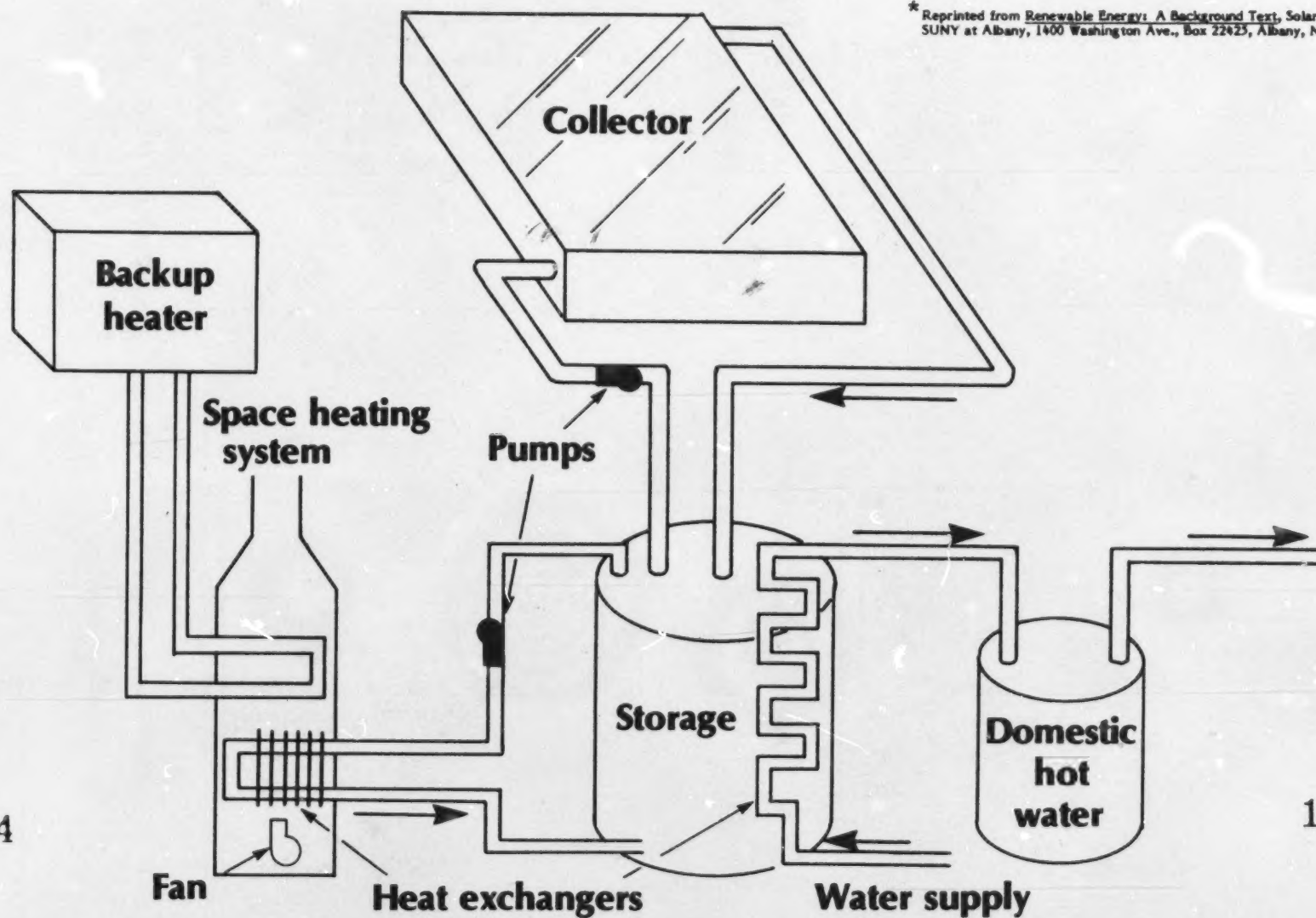


Thermosiphoning Collector

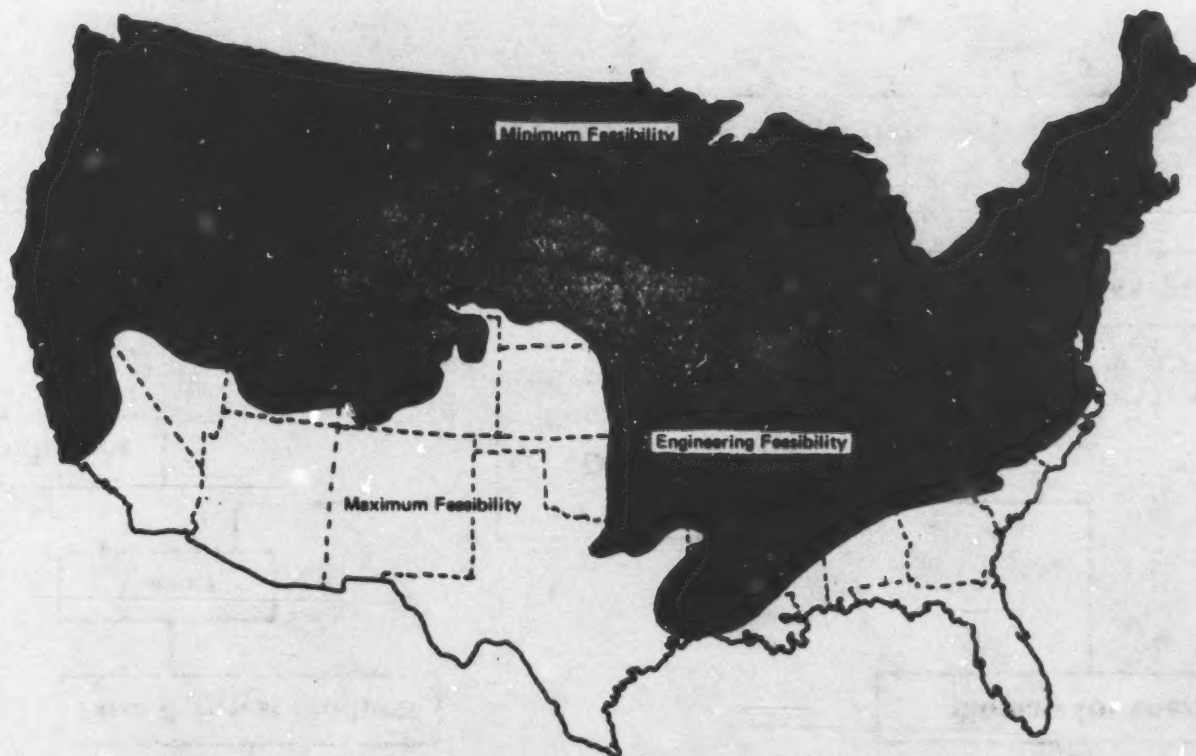
*Reprinted from *Renewable Energy: A Background Text*, Solar Energy Project, SUNY at Albany, 1400 Washington Ave., Box 22425, Albany, NY 12222.

An Active Solar System* with Heat Exchangers

* Reprinted from Renewable Energy: A Background Text, Solar Energy Project, SUNY at Albany, 1400 Washington Ave., Box 22425, Albany, NY 12222.



10. Solar Home Heating Feasibility*

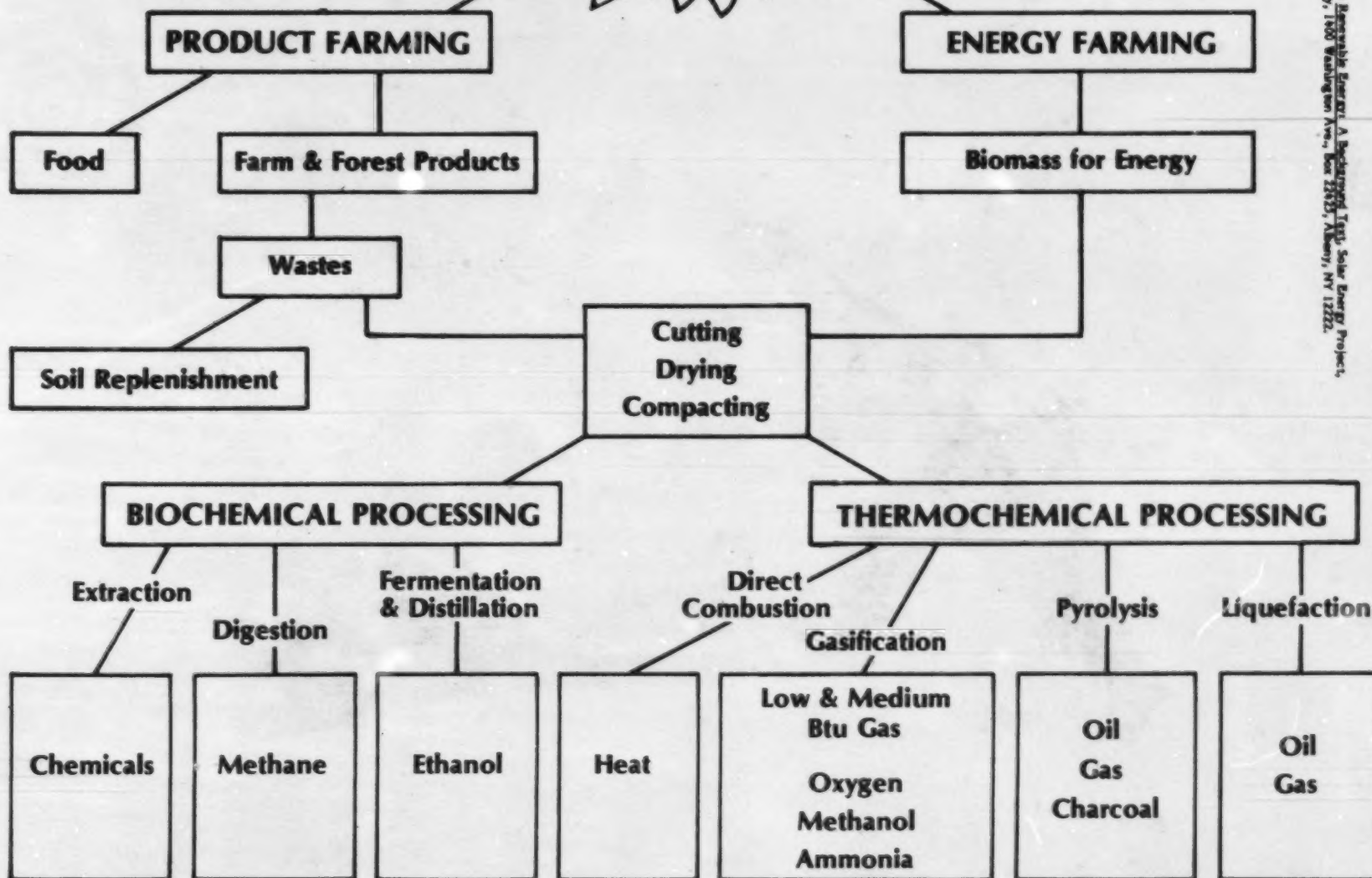


The regions of the different degrees of feasibility of heating houses by solar energy. In the white areas houses may be entirely heated in this fashion; in the light-gray areas a large portion of the heat can be obtained; and in the darker areas only a small part of space-heating needs can be provided by trapped solar energy.

*Reprinted with permission from: Energy Sources, the Wealth of the World. Ayres and Scarlott, McGraw-Hill, New York, 1952.

Energy Products from Biomass

PHOTOSYNTHESIS



Reprinted from *Renewable Energy: A Sustainable Technology*, Solar Energy Project, SUNY at Albany, 1400 Washington Ave., Box 2240, Albany, NY 12222.

12. Wind Speed Measurements

Angle Fishing Line Makes with Protractor	Wind Speed (km/hr.)
90°	0
85°	9.3
80°	13.2
75°	16.3
70°	19.0
65°	21.6
60°	24.0
55°	26.4
50°	30.0
45°	31.5
40°	34.4
35°	37.7
30°	41.5
25°	46.2
20	52.3

13. Available Power from the Wind

Available Power from the Wind in Watts*
(System efficiency of 30%)

Propeller Diameter (m)	Wind Speed (km/hr.)				
	8	16	24	32	40
1.2	2	19	64	152	296
1.8	5	43	144	341	665
2.4	10	76	256	605	1183
3.0	15	119	399	947	1848
3.6	21	170	575	1363	2661
4.2	30	232	782	1855	3623
4.8	38	307	1022	2423	4731
5.5	48	383	1293	3066	5988
6.0	59	473	1597	3785	7393

*Reprinted from Electric Power from the Wind, by Henry M. Clews, Solar Wind Publications, 1972.

14. Location of Geothermal Resources in the U.S.*



• = Areas of Promise

*From: Project Independence Report, Federal Energy Administration,
United States Department of Energy, November, 1974.

140

APPENDIX C — REFERENCES

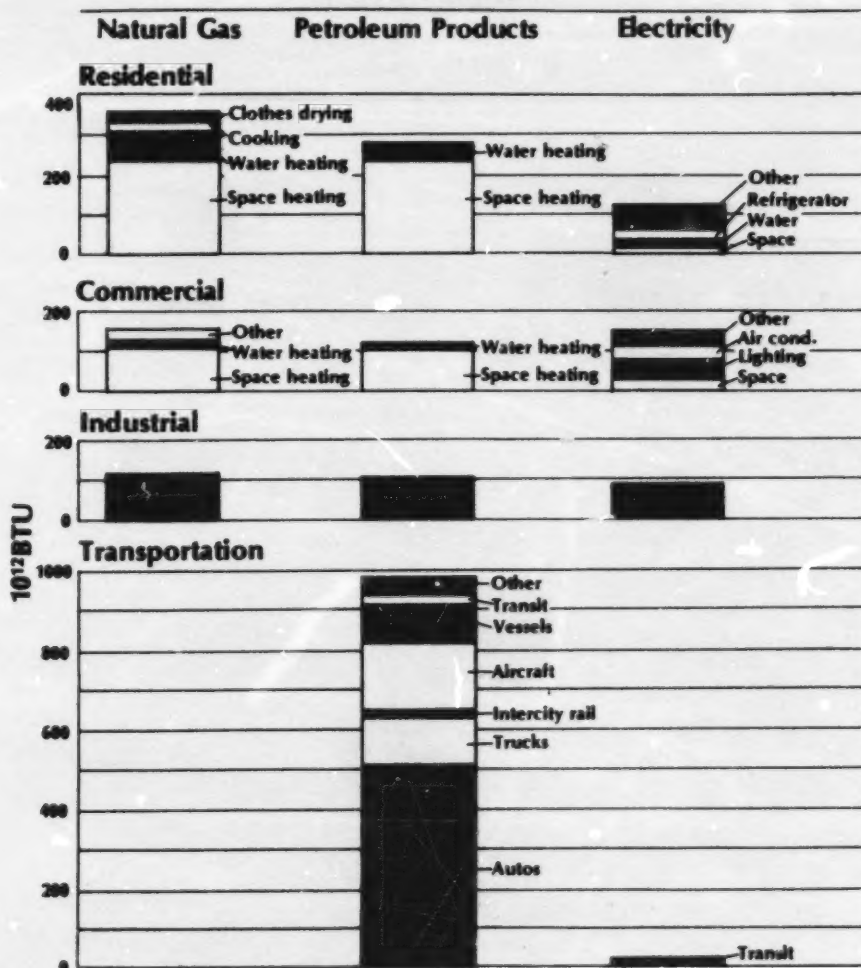
The activities and their sources listed below are those which appear throughout the concept outline. They supplement the outline and, in many instances, the activities found in Appendix B. For those materials whose source is the New York Energy Education Project, availability is contingent upon attending an energy education workshop that can be provided by your area Project Resource Agent. For further information, contact your agent* or the New York Energy Education Project, SUNY at Albany, 1400 Washington Avenue, Box 22100, Albany, New York 12222.

1. The Effect of Surface Color on Heat Absorption. From: Activities: Junior High Science, Solar Energy Education Project, SUNY at Albany, Washington Avenue, Box 22425, Albany, New York, 12222.
2. The Heating and Cooling of Objects by Radiation. From: See C-1 above.
3. Atoms, Nuclei, and Radiation. From: Nuclear Energy, New York Energy Education Project. Basic nuclear physics is presented through readings, modeling activities, a game, and mathematics exercises.
4. Energy in Food. From: Renewable Energy, New York Energy Education Project.
5. Energy in New York's History. From: Fossil Fuels, New York Energy Education Project. Students are apprised of important trends and events in energy history.
6. Petroleum Producing Areas. Refer to: "Oil and Gas Fields in the United States," Exhibit Four, Energy Adventure, AMOCO Educational Services, Mail Code 3705, P.O. Box 5910-A, Chicago, Illinois 60680 and "World Petroleum Producing Areas - 1977," Two Energy Gulfs, Grades 6-7, United States Department of Energy/National Science Teachers Association, March 1979, p. 54.
7. Handling Fuels Safely. From: Fossil Fuels, New York Energy Education Project. Students are alerted to the importance of safety in fuel handling.
8. U.S. Coal Deposits. Refer to: "U.S. Coal Deposits," Exhibit Seven, Energy Adventure, AMOCO Educational Services.
9. How is Energy Released from the Nucleus? From: Nuclear Energy, New York Energy Education Project. Readings and activities are provided to explain the fission process and the working of a nuclear reactor.
10. Uranium Resources. Refer to: Figure 2-10, "Uranium Resources Western United States," Energy-Environment Source Book, National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C. 20009, p. 120.
11. Dealing with Nuclear Wastes. From: Nuclear Energy, New York Energy Education Project. Exercises to teach the nuclear fuel cycle and the types

*See the complete list of resource agents on page 137.

12. Investing Our Energy Dollars. From: Nuclear Energy, New York Energy Education Project. Students are involved in role playing the process of deciding what kind of power plant to build. This is followed by a reading of an actual case.
13. End Uses of Energy, by Fuel, and by Sector: New York 1982. From: Energy Transparency/Ditto Masters, New York Energy Education Project, A 14.
14. Industrial Output and Per Capita Energy Consumption. Refer to: World Development Report, 1980, World Bank, 1818 H Street, N.W., Washington, D.C. 20433.
15. The Appliance Explosion. From: Energy Conservation, New York Energy Education Project.
16. End Uses of Energy. Refer to the graph below while discussing the questions on page 34.

End Uses of Energy, by Fuel and by Sector: 1982 New York State



17. Fossil Fuel and the Environment. From: Fossil Fuels, New York Energy Education Project. Students will investigate such problems as the greenhouse effect, land reclamation, and acid precipitation as they relate to fossil fuel use.
18. Transporting People and Goods. Use the data provided to answer the questions.

ENERGY DATA FOR PASSENGER TRAFFIC - 1970*			
<u>Inter-City</u>			
Mode	Average Passenger Capacity	Average Load Factor	Energy Cost/Intensity (BTU per passenger mile)
Railroad	69/car	35%	2,900
Bus	41	45%	1,600
Automobile	5	48%	3,500
Airplane	106	50%	8,400
<u>Urban</u>			
Mode	Average Passenger Capacity	Average Load Factor	Energy Cost/Intensity (BTU per Passenger mile)
Bicycle	1	100%	200
Walking	---	---	300
Rail (Trolleys, Subways)	?	?	2,300
Bus	55	20%	3,800
Automobile	5	28%	8,500
ENERGY DATA FOR FREIGHT*			
Mode	Energy Cost/Intensity (BTU's needed per ton-mile)		
Waterway	680		
Pipeline (oil)	1,850		
Railroad	700		
Truck	2,800		
Airplane (domestic)	62,000		

•What is the least energy-intensive means of transportation between cities?

(Bus)

•What is the most energy-intensive method of transportation within an urban area?

(Automobile)

•For what reasons do people use more energy-intensive (costly) means of transportation?

•How can we encourage them to use less energy-intensive means?

•Discuss why the two most energy-intensive means of moving goods (truck, airplane) are, nonetheless, the most used.

*From: Energy Conservation- Transportation, Factsheet 11, John M. Fowler. National Science Teachers Association, Washington, D.C.

19. Car Buying: An Energy Decision. From: Fossil Fuels, New York Energy Education Project. Students will consider some of the impacts and interrelationships of energy, economics, environment, and human systems.
20. Home Energy Conservation. Refer to:
 - "A Home Energy Audit," Energy Conservation, New York Energy Education Project.
 - "Insulation: Keeping Heat In and Out," Energy Conservation, New York Energy Education Project.
 - "Window Treatments for Energy Savings," Energy Conservation, New York Energy Education Project.
21. Oil, Natural Gas and Oil Shale Resources. Refer to: Figures 2-4, 2-6, and 2-8, Energy-Environment Source Book, National Science Teachers Association, pp. 116-118.
22. Energy From Fuels. From: Fossil Fuels, New York Energy Education Project. Students will produce methane from coal by destructive distillation.
23. Nuclear Alternatives. From: Nuclear Energy, New York Energy Education Project. Students will consider alternatives such as breeder reactors to the current conventional nuclear reactors
24. A Passive Solar House. From: Renewable Energy, New York Energy Education Project.
25. Solar Energy in a Can. From: Renewable Energy, New York Energy Education Project.
26. A Sun Rights Dilemma. From: Renewable Energy, New York Energy Education Project.
27. Wood: Stored Solar Energy. From: Renewable Energy Activities for Biology, Solar Energy Education Project.
28. Nuclear Fusion: Getting It All Together? From: Nuclear Energy, New York Energy Education Project. Students are given a basic introduction to fusion.

Resource Agents

Lower Hudson Valley

Mary A. Collier
Tri-Valley Central School
contact at:
P.O. Box 931
Liberty, N.Y. 12754
914-292-6329 (after 4:00)

Ellen Curry, R.D.C.
John F. Kennedy High School
Route 138
Somers, N.Y. 10589
914-232-5061

Timothy J. Denman
Newburgh Free Academy
contact at:
69 River Street
Montgomery, N.Y. 12549
914-457-3955 (after 4:00)

Gladys Holland
South Orangetown Central
School
contact at:
P.O. Box 70
Orangeburg, N.Y. 10962
914-359-0771 (after 4:00)

Robert LaRoche
North Salem Middle School
Route 124
North Salem, N.Y. 10560
914-669-5414

Alice Listi
Yonkers City Schools
contact at:
319 Westchester Avenue
Yonkers, N.Y. 10707
914-337-6646 (after 4:00)

Thomas Natoli
M. Clifford Miller Junior High
Fording Place Road
Lake Katrine, N.Y. 12449
914-382-2960

Alice T. O'Keefe
East Ramapo Central School
contact at:
P.O. Box 294
Pomona, N.Y. 10970
914-354-3442 (after 4:00)

Harold Woods
East Ramapo Central School
contact at:
41 Pine Hill Road
Highland Mills, N.Y. 10930
914-627-2469 (after 4:00)

Central New York and Southern Tier

Carol A. Burkhart
St. Johnsville Central School
contact at:
R.D. #1
St. Johnsville, N.Y. 13452
518-568-2177 (after 4:00)

Mary P. Colvard
Sidney High School
95 West Main Street
Sidney, N.Y. 13838
607-563-2135

Gail Kovac
Vestal Hills Elementary School
Country Club Road
Binghamton, N.Y. 13903
607-757-2357

Eleanor Nelson
Syracuse City Schools
contact at:
5250 Longridge Road
Jamesville, N.Y. 13078
315-446-7483 (after 4:00)

Eastern New York

Joanne Gallagher
Tamarac Middle School
Box 220A, R.D. #3
Troy, N.Y. 12180
518-279-3463

Daniel A. Nelson
Shenendehowa High School
P.O. Box 58
Clifton Park, N.Y. 12065
518-885-1685
(home, after 4:00)

Northern New York

Ray J. French
Gouverneur High School
Barney Street
Gouverneur, N.Y. 13642
315-287-1900

Shirley Hewitt
Box 138
Olmstedville, N.Y. 12857

Lois Ploof
Norwood-Norfolk Central
School
contact at:
Star Route
Massena, N.Y. 13662
315-384-4348 (after 4:00)

Western New York

Elizabeth B. Banister
Palmyra-Macedon Middle
School
163 Hyde Parkway
P.O. Box 5
Palmyra, N.Y. 14522
315-597-6602

Arlene Davidson
3 Brookwood Road
Pittsford, N.Y. 14534
716-385-4843

Jerald Graves
Eastridge Junior-Senior
High School
2350 Ridge Road East
Rochester, N.Y. 14622
716-544-9950

Robert Horvat
S.U.C. Buffalo
New Science 132
1300 Elmwood Avenue
Buffalo, N.Y. 14222
716-878-4735/6731

Patricia Pietropaolo
Community College of the
Finger Lakes
Canandaigua, N.Y. 14424
716-394-3500, Ext. 325

Douglas Seager
Monroe B.O.C.E.S. #1
41 O'Connor Road
Fairport, N.Y. 14450
716-377-4661, Ext. 466

J. Richard Sentman
Clarence High School
contact at:
334 Everett Place
Tonawanda, N.Y. 14150
716-837-5504

Long Island

Frank A. Kujawski, Jr.
Mattituck High School
Box 1438
Mattituck, N.Y. 11952
516-298-8471, Ext. 40

Adeline A. Quinn
Long Beach City Schools
235 Lido Boulevard
Long Beach, N.Y. 11561
516-889-2390

Alfred J. Schutte
Wantagh Junior-Senior
High School
Wantagh, N.Y. 11793
516-781-8000, Ext. 261

Cindy Theiss
Babylon Junior-Senior
High School
50 Railroad Avenue
Babylon, N.Y. 11702
516-661-5810

Deyo Trowbridge
East Hampton High School
contact at:
P.O. Box 215
East Hampton, N.Y. 11937
516-324-9641 (after 4:00)

John D. White
West Islip High School
contact at:
35 Franklin Street
Islip, N.Y. 11751
516-581-1737 (after 4:00)

New York City

Israel Baum
James Madison High School
3787 Bedford Avenue
Brooklyn, N.Y. 11229
212-377-0400

Harry F. Betros
Erasmus Hall High School
911 Flatbush Avenue
Brooklyn, N.Y. 11226
212-282-7803

Ellen Goldstein
Junior High School #167
contact at:
450 East 63rd Street
New York, N.Y. 10021
212-775-1322 (after 4:00)

Michael Haas
South Shore High School
6565 Flatlands Avenue
Brooklyn, N.Y. 11236
212-531-4454

Barbara Marans
Yonkers City Schools
contact at:
1 Secor Road
Scarsdale, N.Y. 10583
914-472-6778 (after 4:00)

Mary Beth McCarthy
Bernstein Intermediate School
1270 Huguenot Avenue
Staten Island, N.Y. 10312
212-356-2314

John L. Roeder
The Calhoun School
433 West End Avenue
New York, N.Y. 10024
212-724-1980

Anna Silbermintz
Public School #197
825 Hicksville Road
Far Rockaway, N.Y. 11691
212-327-1083/0610

Sheldon Silbermintz
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212-723-0782/0313

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